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ABSTRACT

As a part of the REACH (Refrigeration, Electro-Mechanical, Air-Conditioning, Heating) electromechanical cluster, this student manual contains individualized instructional units in the area of refrigeration. The instructional units focus on refrigeration fundamentals, tubing and pipe, refrigerants, troubleshooting, window air conditioning, and refrigerators and freezers. Each unit follows a typical format that includes a unit sheet, information sheets, assignment sheets, and job sheets. The unit sheet is designed to guide the learner through each task and is comprised of two main sections. The first lists all information needed to identify the task and the sequence in which activities are performed. The second section identifies each activity. (Related teacher's guides are available separately as CE 026 352-355.) (LRA)

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REACH

REFRIGERATION UNITS

DEVELOPED UNDER CONTRACTUAL AGREEMENT

WITH

DIVISION OF PROGRAM DEVELOPMENT
OFFICE OF VOCATIONAL EDUCATION
GEORGIA DEPARTMENT OF EDUCATION
ATLANTA, GEORGIA 30334
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BY

VOCATIONAL EDUCATION TEACHERS

AND

THE UNIVERSITY OF GEORGIA STAFF

UNDER THE DIRECTION

OF

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TEXT ASSIGNMENT SHEET

REFRIGERATION UNITS

ASSIGNMENT NO.	TEXT NO.	PAGES	STUDY ASSIGNMENT
REF-01a	1	3-5	Read section "Refrigeration Through the Ages"
REF-01b	2	953-954	Read section "Career Opportunities in Refrigeration and Air Conditioning"
REF-02a	2	207-208	Read section 6-77 Review of Safety
REF-02b	2	35	Read section 1-67 Review of Safety
REF-03a	1	15	Read section on "Heat Quantity"
REF-03b	2	22-25	Read sections 1-27 through 1-33 on the types of heat
REF-03c	1	23-30	Read section on pressure and vacuum relationship
REF-04a	1	73-77	Read pages on refrigerant flow control and study illustrations
REF-05a	1	49-55	Study illustrations of basic hand tools and study their use in refrigeration
REF-05b	1	102-105	Read and study illustrations of measuring and testing equipment
REF-05c	3	33-41	Read and study illustrations of electric meters
REF-06a			No text assignment
REF-07a	2	37-39	Read pages and study pipe sizing tables.
REF-08a	1	35-38	Cutting and bending copper tubing
REF-09a			No text assignment
REF-10a			No text assignment
REF-11a	2	278-292	Study the descriptions of different types of refrigerants.
REF-11b	2	292-296	Read paragraphs 9-17 to 9-27.

TEXT ASSIGNMENT SHEET

REFRIGERATION UNITS

ASSIGNMENT NO.	TEXT NO.	PAGES	STUDY ASSIGNMENT
REF-12a	2	70-71	Read paragraph 2-71 "Service Values" and study illustrations
	2	104	Read paragraph 4-11 "Compressor High Side Service Valve: and study figures 4 -10 and 4-11.
	2	134	Read paragraph 4-50 "Service Valves"
	2	454	Read paragraphs 12-61 "Manual Valves" and 12-62 "Condensing Unit Service Valves"
REF-13a	1	350-352	Sections 11-27 Installing a Gauge Manifold
REF-14a	2	55,56,70, 71,104,350 374,495, 506,509	Sections 2-37,2-38,2-71,2-72,2-74,4-9,4-11,11-27,11-55,14-8,14-23,14-31
REF-15a	1	109-112	"Vacuumpumps" and "Deep Evacuation"
REF-16a	1	253	A. Crankcase heaters
	2	108,459-461	B. Filters and Dryers
	1	251-252	C. Heat exchangers
	1	250-251	D. Mufflers
	1	252-253	E. Accumulators
	2	108	F. Receivers
	2	457-458	G. Sight Glass
REF-16b	1	586-589	Read paragraphs on reversing valve and study illustrations

TEXT ASSIGNMENT SHEET

REFRIGERATION UNITS

ASSIGNMENT NO.	TEXT NO.	PAGES	STUDY ASSIGNMENT
REF-17a	2	361-363	Read sections on leak detection
REF-17b	1	82-83	Read paragraphs concerning leak detection
REF-18a	1	82-83	Read sections on Physical Properties and Refrigerants
REF-19a	1	307-308	Read from "Compressors" to "Controls"
REF-20a	1	69-72	Read from "Condensers" to "Receivers" and study illustrations.
REF-21a	1	192-194	Read introductory section up to "Direct Expansion Coil Capacity". Study illustrations.
REF-21b	1	305-307	Read from "Evaporators" to "Condensers"
REF-22a	1	73-74	Read "Refrigerant Controls". Study illustration of automatic expansion valve.
	1	258-259	Read "Metering Devices" through 259. Study illustration of automatic expansion valve.
	1	308-310	"Controls". Read proceudres for troubleshooting.
REF-23a	1	262-263	Read section on capillary tubes
REF-23b	1	309	Read paragraphs dealing with capillaries. Note other problems which may affect the performance of the capillary tube.
REF-24a	1	258-262	Read section on "Metering Devices" through "Adjusting Thermostatic Expansion Valves".
REF-25a			No text assignment.

ASSIGNMENT NO.	TEXT NO.	PAGES	STUDY ASSIGNMENT
REF-26a			No Text Assignment.
REF-27a			No Text Assignment.
REF-28a			No Text Assignment.
REF-29a	1	112-113	Read "Triple Evacuation" and "Charging the System."
REF-30a	2	227-230	Read section 7-31 "Fan Motors" and 7-32 "Shaded Pole Motors," and study wiring schematic on p. 229.
REF-31a	6	114-115	Start at - Now, we are troubleshooting..., end at last sentence of last complete paragraph.
REF-31b	6	312-313	Study troubleshooting chart.
REF-32a	3	60-61	Read section 3.7 "Schematic Diagrams" and study drawings and symbols.
REF-33a			No Text Assignment.
REF-34a	1	112-113	Read section on "Triple Evacuation."
REF-34b	1	111	Read section on "Deep Vacuum method of Evacuation" and study illustration.
REF-34c	1	82-83	Read paragraphs on leak detection.
REF-34d	1	113-114	Read "Charging the System" and "Charging Techniques."
REF-35a	2	9-10	Read sections 1-4 "Cold", 1-5, "Cold Preserves Food," 1-7, "Temperature and temperature measurement," 1-8 "Thermometer scales", and study figure 1-3 "Thermometer Scale Comparison."
REF-36			No Text Assignment.
REF-37			No Text Assignment.
REF-38			No Text Assignment.

MAJOR BLOCK Refrigeration **NAME** ______

TASK Refrigeration Fundamentals

UNIT Career Opportunities **TIME (est.)** ______ **(act.)** ______

UNIT NO REF-01

OBJECTIVE(S)

Identify orally and in writing the many career opportunities available in refrigeration and related fields.

START → W-1 W-2 C-1 W-3 W-4 C-2 W-5 C-3

WRITTEN ASSIGNMENT(S)		**AUDIOVISUAL(S)**	
W-1	Text Assignment REF-01a	A-1	
W-2	Assignment Sheet REF-01a	A-2	
W-3	Text Assignment REF-01b	A-3	
W-4	Assignment Sheet REF-01b	A-4	
W-5	Assignment Sheet REF-01c	A-5	
W-6		A-6	
W-7		A-7	

LABORATORY ASSIGNMENT(S)		**CHECKPOINT(S)**	
L-1		C-1	Instructor Check
L-2		C-2	Instructor Check
L-3		C-3	Instructor Check
L-4		C-4	
L-5		C-5	
L-6		C-6	
L-7		C-7	
L-8		C-8	
L-9		C-9	

List below as many refrigeration systems as possible.

1. (Example) Simple refrigerator designed for household use
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____
9. ____
10. ____
11. ____
12. ____
13. ____
14. ____
15. ____

Write a brief description or outline the various opportunities available in this field:

Obtain from the instructor a course outline and sequence of tasks taught. Write a brief description of the training which should be obtained in this course and career plans after the course has been completed.

MAJOR BLOCK Refrigeration **NAME**

TASK Refrigeration Fundamentals

UNIT Identifying Safe Working Conditions **TIME (est.)** **(act.)**

UNIT NO REF-02

OBJECTIVE(S)

Identify and practice safe working habits in the laboratory and in the workplace.

START ➡ A-1 W-1 W-2 C-1 W-3 W-4 W-5
C-2 W-6 W-7 C-3 W-8 C-4

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-02a
W-2 Assignment Sheet REF-02a
W-3 Text Assignment REF-02a
W-4 Information Sheet REF-02b
W-5 Assignment Sheet REF-02b
W-6 Text Assignment REF-02b
W-7 Assignment Sheet REF-02c
W-8 Assignment Sheet REF-02d

LABORATORY ASSIGNMENT(S)

L-1
L-2
L-3
L-4
L-5
L-6
L-7
L-8
L-9

AUDIOVISUAL(S)

A-1 Slide Set REF-02a
A-2
A-3
A-4
A-5
A-6
A-7

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 Instructor Check
C-5
C-6
C-7
C-8
C-9

Information Sheet REF-02a

Fire Extinguisher Rules

1. Every shop should keep a good fire extinguisher as they are a number one safety device against fires.

2. The extinguisher should always be available, and in good working condition. It should be checked out by an authorized person before being placed in the shop. This is to assure it will work properly when there is a fire hazard.

3. When using a fire extinguisher, direct the stream at the base of the flame, not at the flame itself.

4. Never pull down burning materials with bare hands. Always keep a fire extinguisher near as this will prevent serious handburns.

5. Always use the correct type of extinguisher. For example, never use a water extinguisher on electrical appliances or wires as this may cause serious shock or cause electrocution.

6. Never use the extinguisher for fires that are out of control and too big to handle. The extinguisher can only control small flames.

7. Never throw water on an oil, gasoline, naptha, or grease fire. Water does more harm than good. It only causes these kinds of fires to flame up and spread.

8. Never keep junk or papers in the shop or aisles. In case of a fire or emergency this could prevent workers from getting to safety.

9. Never take chances with a fire when there are flammable and explosive gases around. Always call the fire department.

10. Do not throw matches or leave lighted cigarettes in unsafe areas. These can cause fires in papers, trash, and cause gases to explode if ignited.

11. Be careful in fighting an electrical fire, burning or smoldering insulation, or motors. The stream from a hose or fire extinguisher is a good conductor of electricity therefore causing shock.

12. Change your work clothes as soon as possible if they get oily or covered with gas. They could make a potential torch if any flame or spark is near.

13. Statistics show that most fires are caused by matches and cigarettes. Smoke in designated smoking areas only.

14. Be alert at all times.

Fire Extinguisher Questions

1. Never use a ______________ extinguisher on an electrical fire.
2. Never place a fire extinguisher in a building before it is ________________ by a fire ________________.
3. Always keep a _______ ________________ in the shop in case of a small fire.
4. Never fight flames that are out of ____________________ with a fire extinguisher.
5. Always place the right kind of fire ____________________ in the shop as this is a good ____________ habit.
6. Never leave tools in or on top of ________________ units as they could easily cause __________________.
7. Always wear ____________ and protective clothing when around grinders, ___________, or _______________ as a hot piece of metal could cause you injury.

First Aid

The student must remember that the best first aid measures are the safety precautions that are taken to prevent accidents.

In the event chemical or foreign liquid substances get in the eyes, the best thing to do is rinse and flush eyes for a few minutes and get medical aid as soon as possible. In case of burned eyes, if possible close the eye or hold a shade over them and get medical help as soon as possible.

When a person has fallen or has been struck by a heavy object, lay him or her flat on his or her back with the head slightly tilted back. If needed apply cool towels to area until a doctor can be contacted. If the person is faint lay him or her down and raise the feet.

If the patient is bleeding rapidly stop the bleeding by applying pressure on the following points: on the front of the leg, next to the thigh; for lower leg injuries on the front of the knee; for shoulder and arm apply pressure on collar bone at base of the neck. If these pressure points cannot be found easily, apply a small amount of pressure on the bandage area.

If a person has been injured in the back in any form, it is best not to move them. Make the injured person as comfortable as possible by loosening tight clothing and reassuring them they are going to be alright. Call for medical assistance at once.

1. In case of physical shock caused from fear of an electrical shock, have the injured person lie down if possible and make him or her comfortable with a blanket, coat or any convenient material (a person in shock becomes cool with perspiration). Keep the person quiet and secure medical aid.

2. If a person falls, and breaks a leg, arm or rib, it will be best not to move him or her. Moving and improper handling of the limb can cause serious injury. Keep the person quiet and immobilized and call for medical assistance.

3. In case of a first degree burn caused from working around tools that give off sparks put ice water on the area and apply a dry dressing.

4. In all cases of burns, injuries, or shock seek medical help at once. Emergency telephone numbers should always be posted or easily accessable.

List six injuries which could occur in the lab and list the first aid for each.

1. ____________________ 1. ____________________

2. ____________________ 2. ____________________

3. ____________________ 3. ____________________

4. ____________________ 4. ____________________

5. ____________________ 5. ____________________

6. ____________________ 6. ____________________

Assignment Sheet REF-02c

Safety in Electrical and Refrigeration Occupations

1. Never have your mind on other ____________________ while working with any electrical or dangerous appliances or tools.
2. When discharging a refrigerant system never let the fumes excape into a closed __________________ as this can cause ____________ problems.
3. When checking refrigerant ______________ for ______________ the easiest and safest way is with a ________________ ____ ______________.
4. Never stand in ________________ while working on electrical appliances as this can cause you to be ___________________.
5. Always use ________ __________________ while working on any appliances or refrigerant system as this may avoid ________________ or injuries.

Inspect the laboratory area, listing all unsafe conditions that exist. Also list all work being done by students in an unsafe manner. When this has been completed show the list to the instructor and explain how each unsafe practice should be corrected.

MAJOR BLOCK Refrigeration **NAME** ____

TASK Refrigeration Fundamentals

UNIT Basic Refrigeration Concepts **TIME (est.)** ____ **(act.)** ____

UNIT NO REF-03

OBJECTIVE(S) Demonstrate an understanding of the basic concepts of refrigeration.

START ➡ W-1 ▷ A-1 ▷ W-2 ▷ W-3 ▷ C-1 ▷ W-4 ▷ W-5 ▷ C-2 ▷ W-6 ▷ W-7 ▷ W-8 ▷ C-3 ▷

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-03a

W-2 Information Sheet REF-03b

W-3 Assignment Sheet REF-03a

W-4 Text Assignment REF-03a

W-5 Assignment Sheet REF-03b

W-6 Text Assignment REF-03b

W-7 Text Assignment REF-03c

W-8 Assignment Sheet REF-03c

AUDIOVISUAL(S)

A-1 Slide Set REF-03a

A-2

A-3

A-4

A-5

A-6

A-7

LABORATORY ASSIGNMENT(S)

L-1

L-2

L-3

L-4

L-5

L-6

L-7

L-8

L-9

CHECKPOINT(S)

C-1 Instructor Check

C-2 Instructor Check

C-3 Instructor Check

C-4

C-5

C-6

C-7

C-8

C-9

Refrigeration or cooling is the removal of unwanted heat from a selected place or object and its transfer to another space, place, or object. Removal of heat lowers the temperature and may be accomplished by the use of ice, snow, chilled water or mechanical refrigeration.

Mechanical refrigeration is the utilization of mechanical components arranged in a refrigeration unit for the purpose of transferring heat. Heat exists everywhere in a greater or lesser degree as a form of energy. It can be neither created nor destroyed, although other forms of energy may be converted into heat and vice versa. Heat travels in only one direction, from a warmer to a cooler object or area. Heat cannot travel from a cold body to a hot body. Heat always travels from a substance at a higher temperature to a lower temperature.

Cold is a relative term used to describe low temperature. Cold is something that is produced. Heat is removed and the resulting condition is called cold. A refrigerator produces a condition called cold by removing heat from the inside of the refrigerator compartment. Through the use of the compressor the heat is pumped outside of the unit.

Temperature is the heat level of a substance. It indicates the degree of warmth, or how hot or cold, the substance is. Temperature is measured with the aid of a thermometer. The common thermometer measures heat through a uniform expansion of mercury in a tube.

A thermostat controls the refrigerator and air conditioning system. It is adjusted to the desired temperature, whether it is a central air conditioner unit, or a refrigeration unit.

Ambient temperature is the temperature of the air surrounding a motor or refrigerator or any other operating unit.

Heat may be transferred or moved from one body to another by one of three methods: radiation, conduction, or convection. Some systems of heat transfer make use of a combination of these three methods.

(1) Radiation - The earth receives heat from the sun by radiation. Light rays from the sun are turned into heat as they strike opaque or translucent material which will absorb some of the rays passing through it. A transparent substance such as a glass window pane absorbs little heat as rays pass through it.

Sunlight generates more heat where its rays strike dark colored objects than when it strikes light colored or polished surfaces. A white car is easier to cool than a dark one, and light colored shingles on a house make it a few degrees cooler.

Any heated surface loses heat to cooler surrounding space or surfaces through radiation. Likewise a cold surface will absorb radiated heat.

(2) Conduction - is the flow of heat from one part of a substance to another part of the same substance. Or, the flow can be from one substance to another substance in direct contact with it.

A piece of iron with one end placed in a fire will soon become warm from end to end. This is an example of the transfer of heat by conduction. The heat travels through iron, using the metal as the conducting medium.

Substances differ in their ability to conduct heat, and ones that are poor conductors are called heat insulators. They are used in refrigerators and freezers.

(3) Convection - is the moving of heat from one place to another by a heated substance (fluid or gas). As an example, air or water can be used in convection. The substance is heated and circulated from a heat source to the area it is to heat.

A common example is the use of heat laden air moving from a furnace into the rooms of a house where it releases heat. Then it returns by means of the return air duct and receives another supply of heat from the furnace. An air conditioner works on the same principle, except it picks up heat from the surrounding air and discharges it outside of the unit.

1. Refrigeration is the removal of unwanted __________ from a selected space and transferred to another _____.
2. Heat being a form of ________ cannot be destroyed.
3. When heat is removed the resulting condition is called ____________.
4. ____ is a relative term used to describe low temperature.
5. Heat always travels from a ______ temperature to a _______________ temperature.
6. Heat is pumped out of the refrigeration system by the _______________.
7. A ___________ controls the refrigerator and air conditioning units.
8. The ____________ is used to measure temperature.
9. The ___________ thermometer is normally used to check temperature.
10. __________________ temperature is the temperature of the air surrounding a motor or refrigerator.
11. Heat which brings about a change of state, with no change in temperature is called __________ heat.
12. _______________ heat causes a change in temperature in a substance.
13. _______ is British Thermal Unit.
14. All matter is composed of small particles known as _______________.
15. _______ is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.
16. Name the three physical states which heat exist in ______, ______, ______.

Assignment Sheet REF-03b

Using the formula on page 15 in Text Assignment REF-03a BTU = W x TP = 20 x 4 = 800 B.T.U. Calculate the amount of heat removed if 30 pounds of water is cooled from 80°F to 40°F. Have instructor check answer.

Refer to the formula on page 28 in Text Assignment REF-03c and utilize mercury or water to create a vacuum and blow up a balloon. Have instructor check progress.

Answer the following questions:

1. What is heat, and how is it transformed?
2. How are things made cold?
3. What is a molecule?
4. Which type of heat is used in the refrigeration system?
5. What are the names of the instruments used to measure temperature and control refrigerators and air conditioning units?
6. Name the three physical states of matter.

MAJOR BLOCK Refrigeration **NAME** ____

TASK Refrigeration Fundamentals

UNIT Understanding the Basic Refrigeration Cycle **TIME (est.)** ____ **(act.)** ____

UNIT NO REF-04

OBJECTIVE(S)

Demonstrate an understanding of the basic refrigeration cycle.

START → A-1 → W-1 → W-2 → C-1 → W-3 → C-2 → W-4 → A-2 → C-3 → W-5 → C-4

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-04a
W-2 Assignment Sheet REF-04a
W-3 Text Assignment REF-04a
W-4 Information Sheet REF-04b
W-5 Assignment Sheet REF-04b
W-6 ____
W-7 ____

AUDIOVISUAL(S)

A-1 Slide Set REF-04a
A-2 Slide Set REF-04b
A-3 ____
A-4 ____
A-5 ____
A-6 ____
A-7 ____

LABORATORY ASSIGNMENT(S)

L-1 ____
L-2 ____
L-3 ____
L-4 ____
L-5 ____
L-6 ____
L-7 ____
L-8 ____
L-9 ____

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 Instructor Check
C-5 ____
C-6 ____
C-7 ____
C-8 ____
C-9 ____

There are four major components in the refrigeration system (Figure A).

1. Compressor: The compressor serves two purposes, first it draws the refrigerant from the evaporator and second, it increases its pressure in the compressor and pushes it on, into the condenser.

2. The condenser is a heat exchange unit, in which the heat is picked up by the refrigerants in the evaporators and discharged outside the unit. While the heat is being taken out of the refrigerants, it is turning into cool gas, still in the condenser.

3. The evaporators or cooling coil is part of the system where heat is removed from the air inside the house or refrigerator, by flowing over the cool coils and at the same time, causing the liquid to change into a vapor.

4. The expansion valve acts as a metering device between a high pressure and low pressure. The expansion valve and the compressor are the only two split pressure points in the system. The expansion valve breaks the liquid line into several small lines and actually sprays it into the evaporator. It is located on the outside of the evaporator on the liquid line.

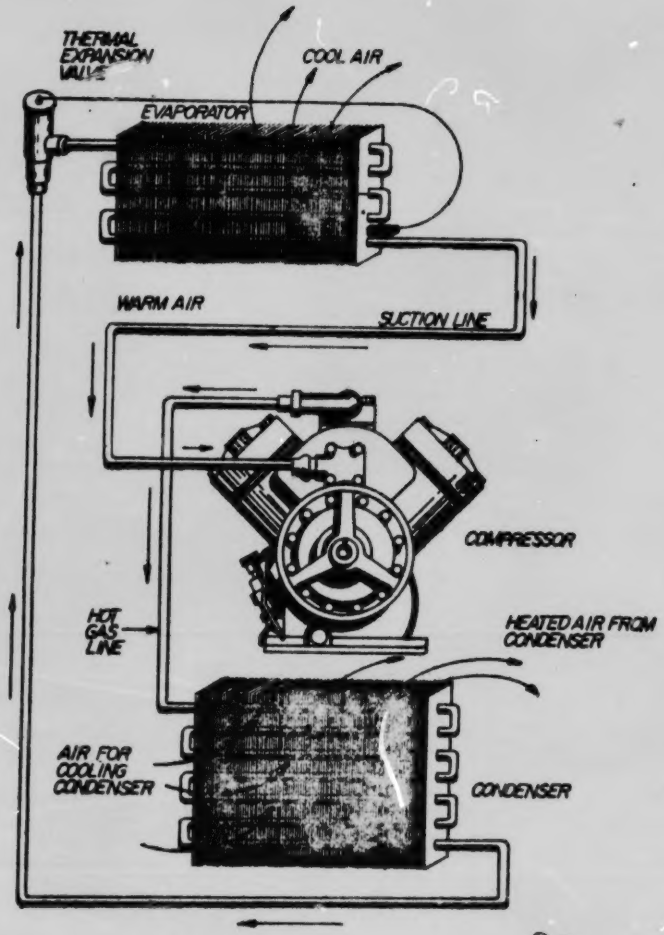


FIGURE A

Assignment Sheet REF-04a

1. What are the two pressure dividing points in the compression system?

2. The ____________________ is where the refrigerants change from liquid to vapor.

3. The compressor forces the refrigerants into the ______________________.

4. The refrigerants continue to ___________ over and over again.

5. The compressor, compresses ____________ only.

6. The high pressure and low pressure cut-outs are located on each side of the _________________________.

7. Hermetic means ___________________.

8. At the metering device, the liquid line changes to several ________________ lines.

9. The metering device is located on the _________________ line in front of the evaporator.

10. The vapor that leaves the evaporator goes into the _____________________.

The Refrigeration Cycle

The typical refrigeration cycle is found in all small refrigerators and small air conditioning units. The principle parts of a refrigeration cycle are the four major components, which were described in Information Sheet REF-04a, the Compressor, Condenser, Evaporator, and Expansion Valve.

As the cold refrigerant liquid moves through the cooling coil, it picks up heat from the air passing over the surface of the coil. When the refrigerant picks up enough heat, it changes to a vapor. The heated refrigerant vapor is then drawn into the compressor where it is subjected to a higher pressure. As a result of being pressurized, the temperature of the vapor increases.

The refrigerant vapor is now at a high pressure and a high temperature. In this state, vapor passes the condenser where heat is removed and the vapor changes back to a liquid; however, this liquid is still under pressure.

The liquid then flows to the expansion valve. As the liquid passes through the valve, its pressure is reduced immediately. The pressure decreases, lowers the temperature of the liquid even more, and it is now ready to pick up more heat.

The cold, low pressure liquid next flows into the cooling coil. The pressure in the cooling coil is low enough to allow the refrigerant to boil and vaporize as it again absorbs heat from the air passing over the coil surface. The cycle then repeats itself as the heated refrigerant vapor is drawn into the compressor.

1. The evaporator is the high side of the refrigerant system.
   True ________ False ________

2. The condenser is the low side of the refrigerant system.
   True ________ False ________

3. The accumulator receives the liquid refrigerant from the evaporator.
   True ________ False ________

4. Is the compressor used as a pump?
   Yes ________ No ________

5. Name the four components used in the refrigerant system.
   1.________________________________
   2.________________________________
   3.________________________________
   4.________________________________

6. The filter drier removes the ____________________ from the refrigerant system.

7. The _________________________________ indicates presence of gas bubbles in the liquid line.

8. The _________________________________ pipe is used to carry refrigerant gas from evaporator to compressor.

9. Gas is a __________________ state of a substance.

10. The liquid receiver is a ______________________ for storage of liquid refrigerant in the system.

MAJOR BLOCK Refrigeration **NAME** ______

TASK Refrigeration Fundamentals

UNIT Identifying Tools **TIME (est.)** ______ **(act.)** ______

UNIT NO REF-05

OBJECTIVE(S)

Identify and examine the proper tools used in refrigeration.

START → W-1 → A-1 → W-2 → L-1 → C-1 → W-3 → W-4 → W-5 → C-2

WRITTEN ASSIGNMENT(S)

W-1 Text Assignment REF-05a
W-2 Information Sheet REF-05a
W-3 Text Assignment REF-05b
W-4 Text Assignment REF-05c
W-5 Assignment Sheet REF-05a
W-6 ______
W-7 ______

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-05a
L-2 ______
L-3 ______
L-4 ______
L-5 ______
L-6 ______
L-7 ______
L-8 ______
L-9 ______

AUDIOVISUAL(S)

A-1 Slide Set REF-05a
A-2 ______
A-3 ______
A-4 ______
A-5 ______
A-6 ______
A-7 ______

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 ______
C-4 ______
C-5 ______
C-6 ______
C-7 ______
C-8 ______
C-9 ______

Electric Tools

Electric tools can be very dangerous is handled carelessly. Caution must be taken at all times, to insure the safety of the mechanic and other workers in the area.

Remember that approximately 90% of all electrical accidents could be avoided if proper precautions are taken.

Rules for Using Electric Tools

1. Never use an electric tool unless it has a proper ground and the correct size wire if an extension cord is used. Cords too small can burn up tools and improper grounded tools can electrocute the operator.
2. Never drill or work overhead without goggles and proper protective clothing. Metal filings are usually hot and can burn through ordinary clothing. A hot piece of metal can cause a person to lose balance on a ladder resulting in a fall.
3. Never drill into a small piece of metal without securing the stock properly. The metal may spin around with the drill bit and injure the operator.
4. Never wear loose clothing around a drill or grinder.
5. Make sure the grinder is properly fastened before operating.
6. Always use proper size drills for the jobs and keep them sharp at all times. Dull bits require extra force which may cause injury.
7. Normally grinders turn down so objects to be ground should be held at the bottom of the wheel and never on the side.
8. Never grind aluminum, copper or other soft metals on a grinder. The metal will fill the grinding stone and prevent proper cooling resulting in the stone flying apart.

Assemble the following tools commonly used by refrigeration technicians. Arrange the tools at your work station in the given order. Show these tools to your instructor.

I. 1. 1/2" combination wrench
   2. 6" No. 2 phillips screwdriver
   3. 6" slip joint pliers
   4. 6" diagonal cutting pliers
   5. 7/16" x 1/2" open end wrench
   6. 1/2" x 9/16" box end wrench
   7. 1/2" flare nut wrench
   8. 6" common screwdriver
   9. 3/8" drive ratchet
   10. 9/16" x 3/8" drive socket
   11. 4 inch 3/8" drive extension
   12. 1/4" Allen wrench
   13. 1/4" capacity portable electric drill
   14. 5/32" drill bit
   15. Pocket dial thermometer
   16. Pressure gauges
   17. Eye protection glasses or goggles.

II. Observe instructor while using the bench grinder.

1. Why is it important to pull on wrenches instead of pushing?

2. What type wrench should be used to disconnect a flare nut on the green line?

3. Why is it important to have a ground wire on electric tools?

4. What is the difference between a flat and phillips screwdriver?

5. What are allen wrenches used for?

6. What are the advantages of using the tube cutter over a hack saw?

MAJOR BLOCK Refrigeration **NAME**

TASK Refrigeration Fundamentals

UNIT Tapping, Threading and Replacing Threads **TIME (est.)** **(act.)**

UNIT NO REF-06

OBJECTIVE(S) Replacing Threads

START	➔	W-1	W-2	W-3	C-1	L-1	C-2	W-4
A-1	W-5	L-2	C-3	L-3	C-4			

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-06a
W-2 Information Sheet REF-06b
W-3 Assignment Sheet REF-06a
W-4 Assignment Sheet REF-06b
W-5 Information Sheet REF-06c
W-6
W-7

AUDIOVISUAL(S)

A-1 Slide Tape REF-06a
A-2
A-3
A-4
A-5
A-6
A-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-06a
L-2 Job Sheet REF-06b
L-3 Job Sheet REF-06c
L-4
L-5
L-6
L-7
L-8
L-9

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 Instructor Check
C-5
C-6
C-7
C-8
C-9

Galvanized pipe is sometimes used as drain pipe on air conditioners and black pipe is always used for gas line for heating units.

Normally, the mechanic should have certain pipe fitting supplies on hand.

1. Pipe joint compound, which is used on joints to prevent leaking.
2. Variety of couplings which are completely threaded on the inside and are used to join two threaded pipes of the same size.
3. Nipples, which vary in length from 2 to 6 inches. The 2 and 3 inch lengths are normally threaded completely on the outside, while the 4, 5, and 6 inch lengths are threaded one inch on each end.
4. Elbows, 45° and 90°, both are threaded one inch on the inside of both ends.
5. T's have 3 openings of the same size and are used to branch off a straight line at a 90° angle.
6. Reducing bushings, 1/2 inch long with threads on both sides, are used to reduce or enlarge pipe 1/4 inch at a time (Example: 1/4" to 1/2").
7. Two wrenches are normally used for tightening pipe to insure a tight fit. One wrench will hold the pipe while the other wrench turns the second pipe. It is important to make sure the joint is not cross-threaded. Even with compound, a cross-threaded joint can leak. Don't back off on a tightened joint because a leak could result.
8. Caps are used to close lines temporarily or permanently.
9. Unions are used to connect the unit to the line. Unions are 3 pieces that can easily be tightened and disconnected.
10. A mechanic should have a vise, threaders and cutting oil on hand. Normally, a length of galvanized or black pipe is 21' long. It will have to be cut and threaded on the job to insure proper fitting.

Standard threads for galvanized or black pipe:

1/4 inch	18 threads per inch
3/8 inch	18 threads per inch
1/2 inch	14 threads per inch
3/4 inch	14 threads per inch
1 inch	11-1/2 threads per inch
1-1/4 inch	11-1/2 threads per inch

Types of Assembly Devices

There are several types of bolts, but all are threaded and have a head. The most common bolt is the stove bolt. It is completely threaded and has either a square head or a pan head with a slot. This bolt is used in central heating and cooling units. It is normally used with a nut and sometimes a washer.

There are two (2) basic washers used in the air conditioning industry: flat washers (which are used to keep the bolt head from going through a hole) and lock washers (which is a split washer used to keep the nut from vibrating loose.

The toggle bolt is threaded all the way with standard threads and has an expansion type device on the end of it. This bolt is used to hang units to hollow walls, such as cement or tile blocks.

The carriage bolt has a rounded head with no slot and a square shoulder under the head, which has to be fitted in the exact square hole, to keep the bolt from turning when tightening the nut. This bolt is normally found on large commercial type units.

Lag screws have bolt heads, normally square, but have screw threads instead of bolt threads. They normally are 1/4" to 1/2" and 1-1/2" - 3" in size. These screws are used to mount large units to wood such as rooftop units.

A set screw has regular bolt threads and is generally 3/8" in diameter or smaller and 3/8" - 1" long. It is used to fasten the pulley to the motor shaft. Normally, set screws have a hex head and are inserted or removed with an allen wrench.

A pop-rivet is normally made out of aluminum and fits a 1/8" hole. A pop-rivet gun has to be used to insert the rivet into the hole. They make good looking work and are used on the sheet metal cover of a unit or in other sheet metal work.

There are several different types of screws. The wood screw normally has a flat counter-sunk head with threads up part of the way. It is used to mount thermostats and other various parts to wood.

The self-tapping screw is a hex head screw used in a chuck on an electric drill to screw two pieces of sheet metal together. It can start its own hole.

The machine screw has bolt threads and is used for fastening two pieces of thick metal together.

Self-tapping screws sometimes have a Phillips Head instead of a hex head. It is a raised head that is cross-notched and must be used with a Phillips screwdriver bit.

It is very important to use the right size screwdriver or wrench on these screws and bolts, because you can mess up the screw head or the threading, or the tool can slip and cause damage to the mechanic.

Assignment Sheet REF-06a

1. A bolt is a round metal rod 1/4" and 1" in length with threads on one end and a ____________________ on the other.

2. A lock washer is used to keep the ____________ from working loose.

3. Name three bolts used in the refrigeration and air conditioning industry. ____.

4. A __________ bolt is used to fasten units to hollow concrete block walls.

5. The _________ bolt is held by the shoulder instead of the head.

6. A self tapping _______ is used to fasten sheet metal together.

7. A ________ screw is used to hold pulleys on the shaft.

8. Name the two different types of heads on a screwdriver _______________, ______________________.

9. The ____________ screw is driven in with a hex-chuck in a drill.

10. A pop-rivet is normally used when fastening two pieces of __________ metal together.

11. A set screw has _______ threads on it.

12. What type head does the set screw normally have? _____________________

13. The lag screw is used to mount large units on ____________________.

14. The self tapping screw normally has a ______________ head.

15. The pop rivet is normally used when fastening two pieces of ______________ metal together.

16. The _____________ head screw can start a hole in thin metal without a drilled hole.

This job sheet is designed to help the student to become proficient in the manipulation of nuts, bolts, and threads, for inspection purposes.

Obtain the following items from the tool room:

- -stove belts with nut-assembly and make sure threads are not messed up
- -1 hex head chuck and drill
- -1 hex head screw, insert chuck in drill and screw in thin metal
- -1-3/4 nipple
- -1-3/4 cap insert, cap on nipple to check the threads
- -1 toggle bolt complete, use 1" head drill hole and install toggle bolt in block wall

Go to tool room and obtain a selection of screws and bolts ranging from #7½ to 10 - 1", and bolts from 3/16" x 1" to 3" x 3". Separate the bolts and catalog according to the size and threads. Have instructor check for accuracy.

Self Check

1. Name five things relating to pipes that the mechanic should have.

   ____________________, ____________________, ____________________,

   ____________________, ____________________.

2. Nipples are how long?

3. What is the main difference in carriage bolts and stove bolts?

4. Of the pipe sizes listed which has the least threads per inch? 1/2" or 1"

5. What three type heads are found on self tapping screws?

The best method to determine the exact size of tap drill to use in an operation is to refer to a table such as the one presented below. A chart similar to this is generally included with a set of taps and dies.

(Thread and Tap Drill Sizes)

Nominal size	Thr'd series	Major diameter, inches	Root diameter, inches	Tap drill to produce approx. 75% full thread	Decimal equivalent of tap drill
0-80	N. F.	.0600	.0438	3/64	.0469
1-64	N. C.	.0730	.0527	53	.0595
72	N. F.	.0730	.0550	53	.0595
2-56	N. C.	.0860	.0628	50	.0700
64	N. F.	.0860	.0657	50	.0700
3-48	N. C.	.0990	.0719	47	.0785
56	N. F.	.0990	.0758	45	.0820
4-40	N. C.	.1120	.0795	43	.0890
48	N. F.	.1120	.0849	42	.0935
5-40	N. C.	.1250	.0925	38	.1015
44	N. F.	.1250	.0955	37	.1040
6-32	N. C.	.1380	.0974	36	.1065
40	N. F.	.1380	.1055	33	.1130
8-32	N. C.	.1640	.1234	29	.1360
36	N. F.	.1640	.1279	29	.1360
10-24	N. C.	.1900	.1359	25	.1495
32	N. F.	.1900	.1494	21	.1590
12-24	N. C.	.2160	.1619	16	.1770
28	N. F.	.2160	.1696	14	.1820
1/4-20	N. C.	.2500	.1850	7	.2010
28	N. F.	.2500	.2036	3	.2130
5/16-18	N. C.	.3125	.2403	F	.2570
24	N. F.	.3125	.2584	I	.2720
3/8-16	N. C.	.3750	.2938	5/16	.3125
24	N. F.	.3750	.3209	Q	.3320
7/16-14	N. C.	.4375	.3447	U	.3680
20	N. F.	.4375	.3726	25/64	.3906
1/2-13	N. C.	.5000	.4001	27/64	.4219
20	N. F.	.5000	.4351	29/64	.4531
9/16-12	N. C.	.5625	.4542	31/64	.4844
18	N. F.	.5625	.4903	33/64	.5156
5/8-11	N. C.	.6250	.5069	17/32	.5312
18	N. F.	.6250	.5528	37/64	.5781
3/4-10	N. C.	.7500	.6201	21/32	.6562
16	N. F.	.7500	.6688	11/16	.6875
7/8- 9	N. C.	.8750	.7307	49/64	.7656
14	N. F.	.8750	.7822	13/16	.8125
1- 8	N. C.	1.0000	8376	7/8	.8750
14	N. F.	1.0000	9072	15/16	.9375

American Standard Pipe Tap Drill Sizes

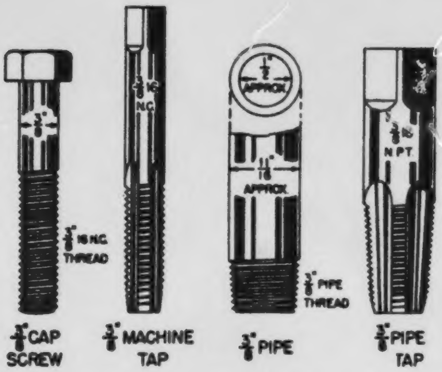
Pipe Tap Size	Tap Drill Size	Pipe Tap Size	Tap Drill Size
1/8	11/32	2	2 3/16
1/4	7/16	2 1/2	2 5/8
3/8	19/32	3	3 1/4
1/2	23/32	3 1/2	3 3/4
3/4	15/16	4	4 1/4
1	1 5/32	4 1/2	4 3/4
1 1/4	1 1/2	5	5 5/16
1 1/2	1 23/32	6	6 5/16

The refrigeration mechanic must be careful when selecting taps and dies. As can be seen on the chart there are fine threads (N.F.) and course threads (N.C.) These are not interchangeable. Always use a thread guage or a nut of known thread design to determine the threads per inch.

Figure A illustrates the difference in pipe threads and bolt threads. These must not be interchanged.

Metric threads also cannot be interchanged with American Standard. Usually metric nuts and bolts are color coded.

When tapping and threading fine, course, pipe, or metric the correct tap and die set must be used for the specific job.



. . —Comparison of machine thread tap and pipe thread tap.

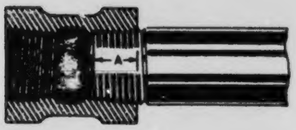
FIGURE A

Comparison of bolt tap sizes and pipe tap sizes

Tapping and Threading

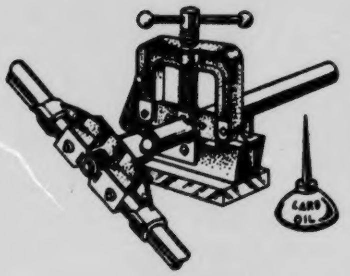
Obtain two pieces of galvanized or black iron pipe and a coupling from the instructor. Use Figure B below and the chart on Information Sheet REF-06c to determine the correct size tap and dimensions.

Thread both pieces of pipe and connect them together with the coupling.



Size of Pipe, Inches	Dimension A, Inches	Size of Pipe, Inches	Dimension A, Inches	Size of Pipe, Inches	Dimension A, Inches
⅛	¼	1½	11/16	5	1¼
¼	⅜	2	¾	6	1 5/16
⅜	⅜	2½	15/16	7	1⅜
½	½	3	1	8	1 7/16
¾	9/16	3½	1 1/16	9	1½
1	11/16	4	1⅛	10	1⅝
1¼	11/16	4½	1 3/16	12	1¾

—Length of thread on pipe required to make a tight joint.

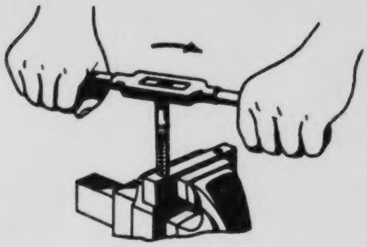


—Threading an external pipe thread with a pipe die.

FIGURE B

Obtain from the instructor one bolt and metal stock. Use the chart on Information Sheet REF-06c to determine the correct drill and tap size.

Drill and tap the stock and screw the bolt down finger tight.



Job Sheet REF-06c

Go to the tool room and obtain bolts with damaged threads. Put solder on the bolt, shaking off excess and insert the bolt in a new nut to determine if the threads are repaired. Have instructor check your work.

MAJOR BLOCK Refrigeration **NAME**

TASK Refrigeration Fundamentals

UNIT Fitting Nomenclature and Pipe Materials **TIME (est.)** **(act.)**

UNIT NO REF-07

OBJECTIVE(S)

Identify the different types of pipe and tube fittings used in refrigeration systems.

START ➡ W-1 W-2 W-3 C-1 L-1 C-2

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-07a
W-2 Text Assignment REF-07a
W-3 Assignment Sheet REF-07a
W-4
W-5
W-6
W-7

AUDIOVISUAL(S)

A-1
A-2
A-3
A-4
A-5
A-6
A-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-07a
L-2
L-3
L-4
L-5
L-6
L-7
L-8
L-9

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3
C-4
C-5
C-6
C-7
C-8
C-9

Types of Pipe and Fittings

Copper tubing is referred to sometimes as soft drawn copper. This form is used because during manufacture it is heated slowly, therefore, causing it to be flexible. Normally copper tubing comes in sizes ranging from 3/16 to 3/4 inch and is used on home refrigerators and air conditioning units. Since the copper tubing is flexible, supports and hangers must be provided for the tubing at all times.

Copper tubing is very easy to work into close places because it will bend easily. Using special forming tools, it can be easily bent up to a 90° angle. It is easily swagged and flared.

Some of the most common used flare fittings are: Standard flare nut, flare coupling, flare 90° elbow, "T" fitting, "Y" fitting, short flare nut, female adapter, plug union, sight glass, half union, long flare nut and adapters to galvanized pipe. (See Figure A).

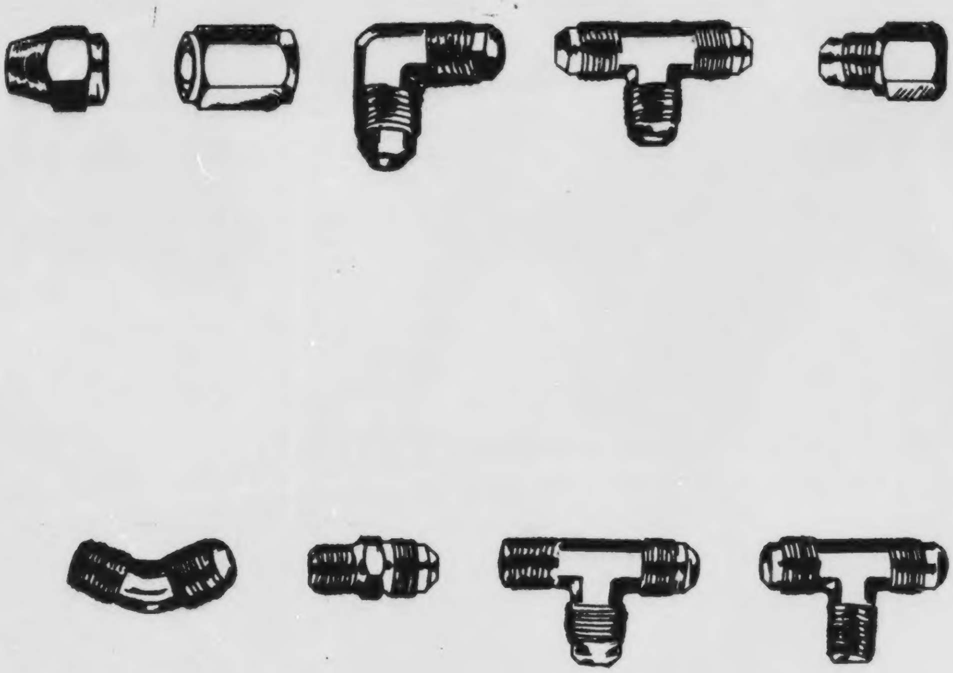


FIGURE A

When soldering soft copper on refrigeration units, it is necessary to use 95-5 or silver solder. All soft copper and fittings should meet the proper requirements because all soft copper cannot be used in refrigeration systems.

Copper pipe normally known as hard drawn copper comes in sizes from 3/8" to 6", but is normally not used on small units requiring 3/4" or below. Instead, soft copper is used. Copper pipe is normally used on large refrigeration systems and air conditioning units. This pipe, being rigid, requires little support. It comes in 20 ft. joints and must be joined by preformed fittings and silver brazed.

All soldered fittings used on copper pipe are sweat type fittings. Examples would be: coupling, 90° elbow, 45° elbow, adapters to galvanized pipe, filters, trap cleanouts, plugs, caps, "T" and "Y" fittings, sight glasses, 60° elbows and test tees. (See Figure B)

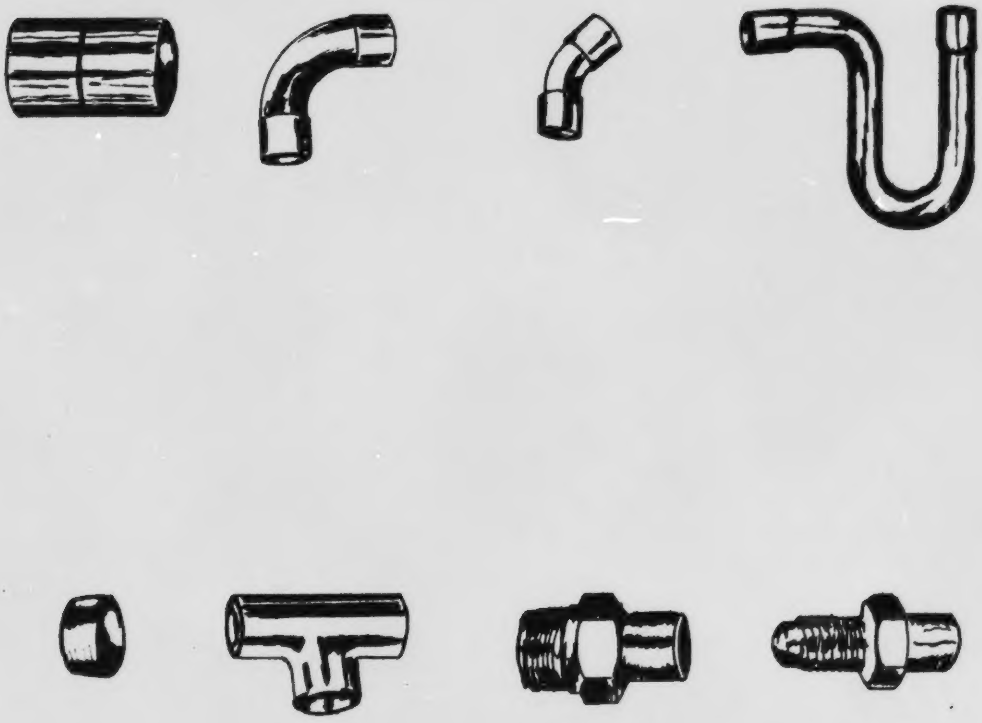


FIGURE B

Soft copper tubing can be connected in various ways. One way is quick coupling, normally used on freon lines on a split air conditioning unit where the unit and line is pre-charged. All the installer has to do is secure the lines properly and the unit is ready to operate (See Figure C).

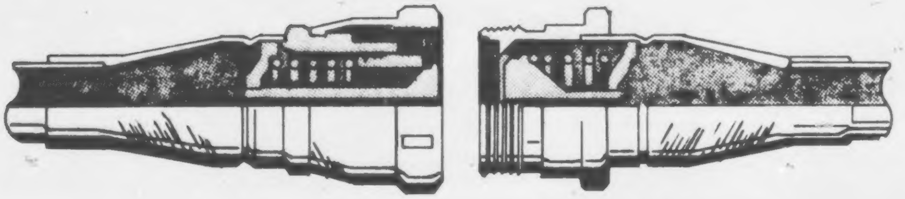


FIGURE C

Copper tubing can be connected with compression fittings, which come in most small sizes. This type fitting is normally used on water lines to the ice maker in a refrigerator, and water lines feeding humidifiers in central air conditioning units. This type coupling requires no soldering or swagging.

The compression joint is composed of a compression sleeve, a compression fitting and a compression nut. (See Figure D.) Compression fittings have a different thread design than flared fittings and therefore cannot be interchanged.

Installation of the compression fitting is accomplished by slipping the correct size nut on the tubing, then sliding on the compression sleeve. The nut is hand tightened until it stops turning. An additional turn with a wrench seals the sleeve. Overtightening will cause a leak.

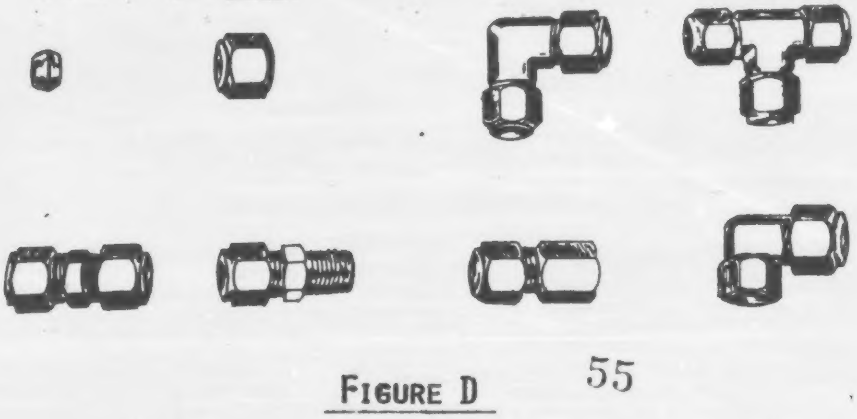


FIGURE D

Stainless steel pipe comes in sizes from 1/4" to 1 1/4" and is very strong, resistant to corrosion, and is connected with flared or swagged joints.

The stainless steel pipe is very expensive and is normally used on special installations such as food processing plants, ice cream manufacture, and milk handling systems.

The joints must be silver brazed using special stainless fittings of similar design to copper fittings, or they may be flared.

PVC is a light weight plastic pipe and is becoming more popular due to the price and ease of work. PVC pipe comes in 10 ft. lengths and ranges in sizes from 3/8" to 6". It is normally used to run water lines to the ice maker on a refrigerator, condensate lines on a central air conditioning unit, water lines on gas central units, and water lines on commercial units. The PVC is very easy to join. It requires only a primer and solvent on the fittings before assembly. If proper procedure is followed, such as cleaning pipe and applying primer first, and then solvent, the joint will never leak.

Secure the fittings listed from the supply room and place the name of the fitting in the space provided. State the size of the fitting for each end. (Example, 1/4 x 3/16.) Be prepared to show these fittings with proper name and size to the instructor.

A. Five Flare Fittings — Size

1. ______________________________ ____ X ____
2. ______________________________ ____ X ____
3. ______________________________ ____ X ____
4. ______________________________ ____ X ____
5. ______________________________ ____ X ____

B. Three Adapters (Flare to Pipe) — Size

1. ______________________________ ____ X ____
2. ______________________________ ____ X ____
3. ______________________________ ____ X ____

C. Four Sweat Fittings — Size

1. ______________________________ ____ X ____
2. ______________________________ ____ X ____
3. ______________________________ ____ X ____
4. ______________________________ ____ X ____

D. One Quick Coupling — Size

1. ______________________________ ____ X ____

E. Five Compression Fittings — Size

1. ______________________________ ____ X ____
2. ______________________________ ____ X ____
3. ______________________________ ____ X ____
4. ______________________________ ____ X ____
5. ______________________________ ____ X ____

F. Five PVC Fittings — Size

1. ______________________________ ____ X ____
2. ______________________________ ____ X ____
3. ______________________________ ____ X ____
4. ______________________________ ____ X ____
5. ______________________________ ____ X ____

MAJOR BLOCK Refrigeration **NAME**

TASK Tubing & Pipe

UNIT Basic Copper Tubing Operations **TIME (est.)** **(act.)**

UNIT NO. REF-08

OBJECTIVE(S)

Cut and bend soft and hard copper tubing.

START → W-1 A-1 L-1 C-1 W-2 W-3 C-2 A-2 L-2 C-3

WRITTEN ASSIGNMENT(S)

W-1 Text Assignment REF-08a
W-2 Information Sheet REF-08a
W-3 Assignment Sheet REF-08a
W-4
W-5
W-6
W-7

AUDIOVISUAL(S)

A-1 Slide Set REF-08a
A-2 Slide Set REF-08b
A-3
A-4
A-5
A-6
A-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-08a
L-2 Job Sheet REF-08b
L-3
L-4
L-5
L-6
L-7
L-8
L-9

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4
C-5
C-6
C-7
C-8
C-9

1. Obtain proper materials and tools from the tool room that is needed to make one flared fitting and five swaged joints. The flaring block should be used for both joints.

2. Cut 6 pieces of tubing 3" long and ream each end thoroughly. Flare one piece, apply the flare nut, and swage the remaining pieces.

3. Have the instructor check the flare and swedging.

4. Flatten one end of the pipe. This will serve to close the pipe for pressure testing. (Soldering should not be done at this time).

Bending Small, Soft Copper Tubing

Tubing can be bent with proper accuracy if the right tools are used and proper caution is taken. It is very important not to bend or crimp the tubing because it will restrict the flow of freon through the system. When starting to bend the tubing with the spring bender always bend the outside first while continuing to pull slowly on both ends until the right bend is reached.

Never get in a hurry when bending tubing and never use a piece that is bent or damaged in any way.

When using the large bender be sure to select the right size wheel on which the tubing will be bent. Again, remember that it should be done slowly to avoid crimping the tubing.

1. When is a swage joint used?

2. When swaging a joint, how high should the tubing stick above the block?

3. Which tool is normally used to cut copper tubing and why?

   A. 1/2" OD
   B. 3/4" OD

4. What two types of benders are used for bending small, soft copper tubing?

5. At what angle should a flare be bent?

Job Sheet REF-08b

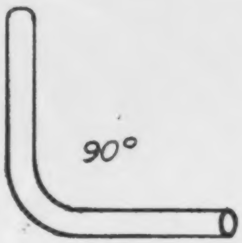
1. Use the previous information sheets and audio-visuals as a guide to bending the tubing.

2. Obtain the following tools from the tool room:

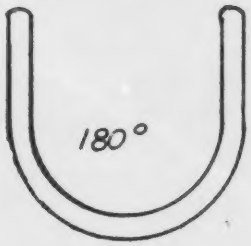
   A. small tubing cutter
   B. spring bender
   C. length of 3/8" pipe

3. Cut two pieces of pipe 16" long. Bend one at a 90° angle (Figure A-1) and the other as close as possible to 180°. (Figure A-2)

4. After completing, check with the instructor for following instructions.



A-1



A-2

MAJOR BLOCK Refrigeration **NAME** ____________

TASK Tubing and Piping

UNIT Soft Soldering Copper Tubing **TIME (est.)** ________ **(act.)** ______

UNIT NO REF-09

OBJECTIVE(S) Swage, clean, flux and soft solder copper tubing using 50-50 and 95-5 solders.

START → W-1 L-1 C-1 W-2 W-3 A-1 L-2
C-2 L-3 C-3

WRITTEN ASSIGNMENT(S)		**AUDIOVISUAL(S)**	
W-1	Information Sheet REF-09a	**A-1**	Slide Set REF-09a
W-2	Information Sheet REF-09b	**A-2**	
W-3	Information Sheet REF-09c	**A-3**	
W-4		**A-4**	
W-5		**A-5**	
W-6		**A-6**	
W-7		**A-7**	
LABORATORY ASSIGNMENT(S)		**CHECKPOINT(S)**	
L-1	Job Sheet REF-09a	**C-1**	Instructor Check
L-2	Job Sheet REF-09b	**C-2**	Instructor Check
L-3	Job Sheet REF-09c	**C-3**	Instructor Check
L-4		**C-4**	
L-5		**C-5**	
L-6		**C-6**	
L-7		**C-7**	
L-8		**C-8**	
L-9		**C-9**	

Soft Soldering Copper Tubing

Soldering is one of the many important tasks that the refrigeration mechanic must perform. Soldering is used to "heat bond" two pieces of metal together in a lead proof assembly. The two methods of soldering used in refrigeration work are hard soldering (also called silver brazing) and soft soldering. This unit will emphasize the soft soldering technique.

Safety Tips

1. Never solder in a closed area, unless properly vented, the fumes from the flux are toxic.
2. Never solder overhead unless eyes, face and body are properly covered.
3. Always protect surrounding components and combustible materials from the heat of the torch. A piece of sheet metal will make a good shield.
4. Make sure torch and tank are checked and clean.
5. Prepare the metal surfaces before lighting the torch.

Tips on Lighting and Adjusting the Torch (Refer to Figure A)

1. Crack the gas valve and use a striker to ignite the gas.
2. Adjust the flame to a bluish green color, if the proper flame cannot be obtained check for dirt in the orifice tip. Check to see if gas cylinder is empty.

NOTE: Never try to solder with an improper flame, carbon will build up on the joint and prevent the solder from sticking.

3. The type of torch determines how the orifice is cleaned. The type shown in figure A is cleaned by a tip cleaning tool. The tool consists of various size wires. Select the correct size wire and work it in and out of the orifice. This should clear out any foreign particles.

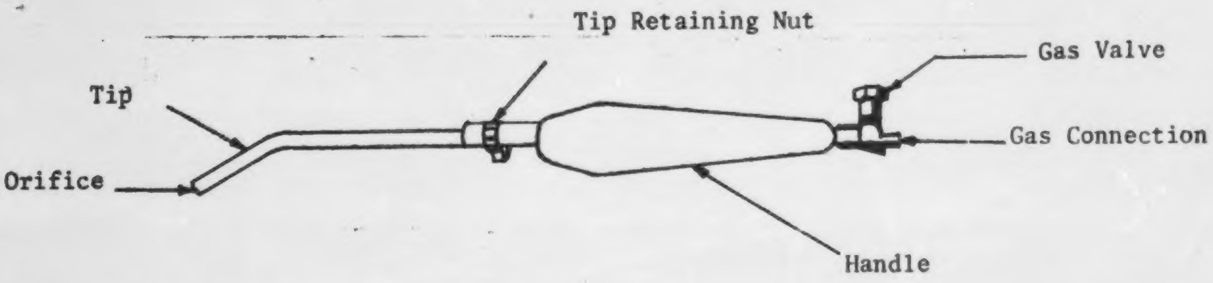


FIGURE A

To clean a portable propane type torch (figure B) take the top part of the torch off, remove the orifice, turn it over and put it back into place. Hold the torch securely and crack the valve slowly - - this should clear out any foreign particles from the orifice. If an air hose is available, it may be used to assist in the cleaning.

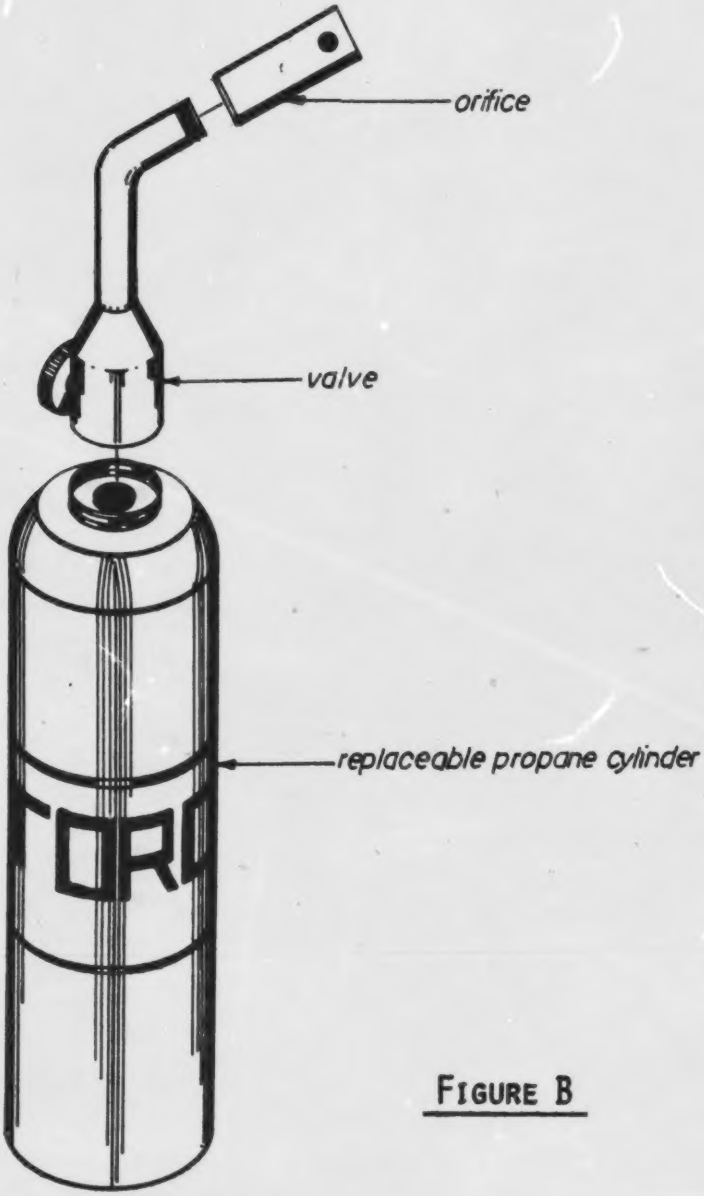


FIGURE B

Soft solder is generally a combination of two metals. The most common being tin and lead. The ratio of the two metals determines the melting point of the solder. A solder that contains 50% tin and 50% lead will melt at 350°F. A solder termed 60-40 would be 60% tin and 40% lead, and have a slightly higher melting point. Tin lead solders are generally used in heating and plumbing work; however, because of the high pressures of the refrigeration system a soft solder consisting of 95% tin and 5% antimony is used (95-5). The melting point of this solder is 450°F. Never attempt to use a solder that is softer than 95-5 in refrigeration work.

Once copper is cleaned and brightly shined it immediately begins to oxidize. This oxidation will prevent the solder from sticking to the metal. A powdered or liquid substance called flux is used to remove oxidation and other impurities. Never attempt to solder without flux. Some solders will contain flux such as rosin core flux used in electronics work and acid core flux used in general repair work. Whether the solder contains flux or not, always use a separate brush on type flux when soldering copper tubing.

Preparing Surface for Soldering

1. Always use a coupling or swage the joints to be soldered.

2. Swaging a joint of soft copper permits two pieces of tubing the same size to be joined together without the use of a coupling. A swaged joint is simply enlarging one end of the copper tubing and sliding the other one inside.

3. Swaging is a common practice because it is easier and quicker to solder one joint that to use a coupling or flare fittings.

4. The tubing can be swaged by using a flaring block and took, except a different die is used in order that the swag will be deep enough. A good rule to remember is to lap the swage joint the width of the copper tubing, ½ pipe would have a ½" swage or joint. (See Figure B)

5. Never solder two pipes together when one is larger than the other, unless some type of constrictor is used. An example of a type of constrictor is the wheel on a tubing cutter that presses the tubing uniformly all the way around the pipe. If this is not done the solder will run inside the large pipe and on into the end of the small pipe restricting the flow of freon.

6. To obtain a good soldered joint the tubing must be cleaned properly. Clean the surfaces to be soldered with a wire brush or emory cloth. Both pieces are then wiped off thoroughly before fluxing. Remember flux does not clean the metal. Rather, it keeps the metal clean after is has been sanded or brushed as mentioned above.

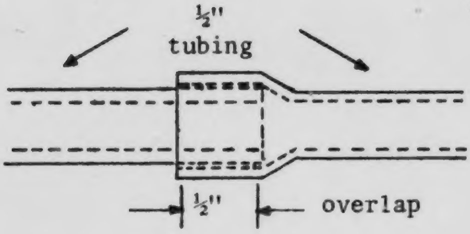


FIGURE B

SWAGED FITTING

Lighting and Turning Off Torch

1. Turn the gas on at the tank.
2. "Crack" the gas valve at the torch handle.
3. Turn pressure regulator to read 4-5 psi.
4. Use a striker to light the torch.
5. Adjust the flame to a soft hissing noise and a bluish-green color.
6. Check with instructor.
7. Turn gas off at the torch handle.
8. Turn gas off at the tank.
9. Crack the gas valve at the torch handle to bleed lines.
10. Close torch gas valve.

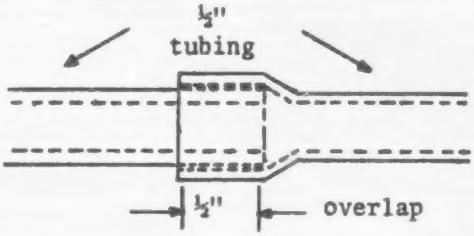
Job Sheet REF-09b

Preparation of Tubing for Soft Soldering

1. Use previous information sheets and audio visual as a guide in preparation of tubing.
2. Obtain the following tools and materials from the supply room:

TOOLS:	MATERIALS:
one tubing cutter	one ¼" x 6" soft copper tubing
one swaging tool	one ½" x 6" soft copper tubing
one wire brush	one 5/8" x 6" soft copper tubing
	one can of flux
	one piece of sand paper or emory cloth

3. Cut and de-burr tubing so as to have two 3" pieces of each size.
4. Swage one piece of each size. Remember that the overlap should be equal to the diameter of the pipe.



5. Carefully clean and polish all surfaces to be soldered.
6. Flux pieces and connect together. DO NOT SOLDER.
7. Check with instructor before proceeding.

Job Sheet REF-09c

Soft Soldering Copper Tubing

1. Use previous information sheets and audio visuals as a guide in soldering.

2. Obtain the following materials and tools from the supply room. Use pipe connections prepared in the previous job.

Tools:	Materials:
one torch	one spool of 50-50 solder
one pair of gloves	one spool of 95-5 solder
one pliers	

3. Mount pipe connection in a holding fixture. Caution: do not distort tubing by squeezing to tight.

4. Use 50-50 on the first connection then 95-5 on the following connections observe melting points.

5. Allow connections to cool then clean and inspect.

6. Check with instructor.

MAJOR BLOCK Refrigeration **NAME** REF-10

TASK Tubing and Piping

UNIT Silver Brazing **TIME (est.)** ______ **(act.)** ______

UNIT NO REF-10

OBJECTIVE(S)

Demonstrate the proper technique for silver brazing on refrigeration piping.

START ➔ W-1 ➔ W-2 ➔ A-1 ➔ W-3 ➔ W-4 ➔ C-1 ➔ L-1 ➔ C-2

WRITTEN ASSIGNMENT(S)		AUDIOVISUAL(S)	
W-1	Information Sheet REF-10a	A-1	Slide/Tape REF-10
W-2	Information Sheet REF-10b	A-2	
W-3	Information Sheet REF-10c	A-3	
W-4	Assignment Sheet REF-10a	A-4	
W-5		A-5	
W-6		A-6	
W-7		A-7	

LABORATORY ASSIGNMENT(S)		CHECKPOINT(S)	
L-1	Job Sheet REF-10a	C-1	Instructor Check
L-2		C-2	Instructor Check
L-3		C-3	
L-4		C-4	
L-5		C-5	
L-6		C-6	
L-7		C-7	
L-8		C-8	
L-9		C-9	

Silver brazing is one of the best methods of making leak-proof connections on copper tubing. It is also strong and will stand up under most any extreme temperature conditions.

The oxy-acetylene torch is normally used in brazing, but it can be dangerous if not used properly. When using a torch always have the cylinder in a vertical position. It has a porous filler wet with acetone, in which the acetylene is dissolved. If not kept vertical the acetylene will "ooze" out causing a dirty flame and grease up the regulator and valves.

Always keep flame away from anything flammable such as oil, wood, paper, paint, cleaning fluids, methyl chloride, or any type cylinder or tank that may have contained gas at one time. Also never heat concrete with torch. Always use the torch at a pressure of 15 lbs. per sq. in. or less, due to the fact that high pressure could cause an explosion.

Lighting Tips

1. Always use a torch lighter, never a match.
2. Open the torch acetylene valve approximately one-quarter turn. The torch oxygen valve is then "cracked" open as you strike the lighter in front of tip.
3. Once torch is lit, the acetylene valve is adjusted to obtain the desired flame size. The oxygen valve is turned slowly to establish the desired flame.
4. The correct flame is called a neutral flame, that is it has a luminous blue cone with a touch of reddish purple at the tip.
5. If the flame is not adjusted properly it is almost impossible to braze the joint. A greenish flame is caused by too much oxygen, which produces soot or carbon, which will restrict the flow of solder on the joint. An oxidizing flame results from too much oxygen, and it will cause pitting or tends to harden the joint.

The turning off procedure is reverse of the starting procedure.

The acetylene tank is always smaller than the oxygen tank. The oxygen hose is green and is right handed, but the acetylene is red and left handed (on the end next to torch).

Safety

1. When finished using the torch always cut it off.
2. Never lay it down on anything flammable.
3. Never solder a line with pressure or vacuum on it.
4. Never solder with torch in closed area.
5. When soldering overhead always wear goggles and proper clothing.

Brazing is a process of applying molten (melted) metal to metals that are heated, but not molten. It is an adhesion process. (In adhesion one part is bonded to, or is stuck to another by a third material). The molten silver solder flows into the pores of the surface of the metals being joined, and as the solder hardens, a good bond is obtained.

The main difference in a brazed joint and soldered joint is the temperature at which the silver solder flows. Silver solder or brazing melts at 1100°F and flows at 1150°F. Regular 50-50 tin and lead melts at 360°F and flows at 415°F. Ninety-five-five tin and antrimony melts at 450°F and flows at 465°F.

The melting point of copper is 1981°F so there is at least a 900°F differential before the copper begins to melt. Therefore silver solder or silver brazing works good on copper pipe and tubing.

Brazing is done by the acetylene torch, with a large torch head. Always use a good paste flux and the flux will dry out at 212°F, and next it will bubble at about 600°F, and at about 800°F, the flux lies on the surface, and has a milky appearance and then into a clear liquid, which is about hot enough to melt the silver solder.

Before brazing a pipe, all air must be removed from the tubing being brazed. This is normally done by purging the tubing with either carbon-dioxide or nitrogen. If there is any oil inside the tubing, the heat of the torch may cause the oil to vaporize. Oil vapor mixed with air will explode if ignited.

Copper and steel are seldom brazed together. However, on some jobs such as in a milk processing plant special cooling systems are needed. These systems require the use of steel piping which can be used easily if the right fittings and the proper procedures are used:

1. Pipes must be the same size thickness.
2. Make sure the flux will adhere to both copper and steel.
3. Use a larger torch.

A silver brazed joint will normally require less work than a welded joint due to the fact that it takes less heat to melt the silver solder than it does to melt metals (such as with the welding process). In addition, the faster the solder melts while brazing, the better the joint is. For that reason most welders use a larger torch than used when brazing copper to copper.

The basic safety rules should be enforced as in soldering and welding. Also, the same cleaning rules apply except to be sure the flux used will adhere to both copper and steel.

Questions

1. No strains should be placed on the joint during ______________ and________.

2. Stirring the flux good before using is a requirement. True_____False______.

3. When the flux on the tube adjacent to the joint has melted to a clear __
_____________ transfer heat to the _________________.

4. Silver solders start to flow at what temperature? _________ to __________.

5. What is used to light the torch? ______________ or ________________.

6. Do you use matches to light a torch? Yes_______ No ____________

7. Always open the torch acetylene valve ______________ of a turn.

8. The correct flame is called a neutral flame. True______ False_________.

9. Underline the correct flame color of the torch.
   A. Blue cone with reddish-purple tip.
   B. Greenish with touch of yellow.
   C. Yellow

10. Never attempt to ____________________ or ____________________ while the system is under pressure or vacuum.

11. The red acetylene hose is the ________ hand thread on the Oxyacetylene brazing equipment.

1. Have student go to tool room and draw following tools and equipment.

   A. One oxy-acetylene torch with large tip or head.
   B. One roll silver solder.
   C. Flux (with brush)
   D. Lighter for torch
   E. Silfos
   F. 2 pieces of copper tubing 1/4" - 3/8"
   1/2", 5/8" and 1" (2 pieces each)

2. Go through the proper procedures and clean and braze the 1/4", 3/8", 1/2", and 5/8" pipe with silver solder.

3. Use silfos to braze the 1" piece.

MAJOR BLOCK Refrigeration **NAME** ______

TASK Refrigerants

UNIT Handling Refrigerants **TIME (est.)** ______ **(act.)** ______

UNIT NO REF-11

OBJECTIVE(S)

Demonstrate a knowledge of characteristics of refrigerants, in handling, transferring, weighing and measuring.

START ➡ W-1 W-2 W-3 W-4 A-1 W-5 C-1 L-1 C-2 L-2 C-3

WRITTEN ASSIGNMENT(S)

W-1 Text Assignment REF-11a
W-2 Information Sheet REF-11a
W-3 Information Sheet REF-11b
W-4 Text Assignment REF-11b
W-5 Assignment Sheet REF-11a
W-6
W-7

AUDIOVISUAL(S)

A-1 Slide Set REF-11a
A-2
A-3
A-4
A-5
A-6
A-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-11a
L-2 Job Sheet REF-11b
L-3
L-4
L-5
L-6
L-7
L-8
L-9

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4
C-5
C-6
C-7
C-8
C-9

Group One Refrigerants

Group one is the safest of all groups. It is probably the most used of all. Some of the most commonly used of group one refrigerants are:

1. R-11
2. R-12
3. R-22
4. R-500
5. R-502

The most commonly used of these are R-12, R-22 and R-502. R-12 is most commonly used for household refrigeration, R-22 for air conditioning, and R-502 for low temperature. All three are used in commercial and industrial uses but very little 502 is used in home use.

Group Two Refrigerants

Group two refrigerants are toxic. They are irritating to breathe and may be flammable. These should have special care in handling and use.

Refrigerants in group two are: (boiling temperature at ATM)

1. R-717 - Ammonia
2. R-1130 - Dichlorethylene
3. R-160 - Ethyl chloride
4. R-40 - Methyl chloride
5. R-611 - Methyl formate
6. R-764 - Sulphur dioxide

Group Three Refrigerants

These are the most dangerous refrigerants of all three groups. They are explosive and combustible when mixed with air or ignited. Three of the better known refrigerants of this group are:

1. R-600 - Butane
2. R-170 - Ethane
3. R-290 - Propane

Great care must be exercised in using these refrigerants.

Information Sheet REF-11b

The refrigerants (generally called freon) in all three groups must all be handled with care, even group one, because of the low boiling points of some of them. For example, R-502 boils at sea level. This means that each time that some of the liquid is turned out of a tank of R-502 the liquid will become warmer than 40° and will boil. The container used must be safe. Some of the things to watch for are:

1. Liquid on any part of the body, most of all the eyes, because of freezing.
2. Putting liquid in the wrong type of container could cause the container to burst and splash on some one.
3. Because they will combine with oxygen in the air, refrigerants will cause suffocation. Freon will settle in a low place like a basement or bottom of a reach-in freezer.
4. Liquid or vapor coming in contact with a flame. Even group I when it comes in contact with a flame changes its state and is no longer freon, but is a FO2 gas which could be toxic, poisonous and acidosis.
5. Freon should never be released inside a house that might have a low room or basement apartment with someone sick in it, because oxygen might be displaced or come in contact with an open flame.
6. Always wear safety glasses for protection of eyes.
7. Never use oxygen or acetylene to pressurize a system because of danger of explosion.
8. Never pressurize anything above its test pressure or recommended pressure.
9. Never put too much liquid in a container--never guess, always weigh.
10. Strap all pressurized tanks to wall when not in use.
11. Never haul a tank without the safety cap on the tank.

Above all, stop and think before handling any type of refrigerant. Know the properties of refrigerants and their reactions under different conditions. If in doubt, check with a safety person or instructor.

1. Name two things that might happen when refrigerant is improperly removed from a unit.

2. What are four methods to measure the amount of refrigerant?

   1.
   2.
   3.
   4.

3. Refrigerants are normally introduced into systems by two methods? What are they?

   1.
   2.

4. The determining factor in the selection of the method of removing and storing system refrigerant is usually:

   a. system size
   b. economics
   c. system valves
   d. available space

5. When releasing a halogenated hydrocarbon refrigerant to the atmospheric pressure why should ample ventilation be provided.

6. Name 3 different things that can be done with the refrigerants, that must be removed from a system?

7. Always fill a tank full? True or False

8. When will freon need the most space to occupy as a liquid? Why?

9. When transferring freon that has been used before, what should be in the line you are transferring it through?

Checking Gas in the Service Cylinder

Job Sheet REF-11a

1. Tools
    - A. Manifold gauges and hose
    - B. Temperature thermometer
    - C. Corresponding temperature to pressure chart
2. Procedure (check with instructor before hooking up guages)
    - A. Check the pressure on 3 tanks of gas in the shop and fill out data on each tank.
    - B. Check gas in service cylinder. Fill out data sheets.

	Unit #1	Unit #2	Unit #3
Ambient temperature			
Gas pressure			
Gas temperature			
From corresponding temperature to pressure chart			
Type of gas in system			

Service Cylinder

	Unit #1	Unit #2
Ambient temperature		
Gas pressure		
Gas temperature		
Corresponding temperature to pressure		
Type of gas in cylinder		

Filling the Service Cylinder

Job Sheet REF-11b

1. Tools and Materials

   A. Service cylinder
   B. Tank of gas
   C. Manifold gauges (check with instructor before using).

CAUTIONS: Never fill over 80% of capacity of any tank or drum or service cylinder. Leave room for expansion. Be safe.

2. Procedure

   A. If there is already liquid in the service cylinder, check pressure and determine what type of gas is in the cylinder (confirm this with the instructor before going any further.)

   B. Add liquid to service cylinder or take out according to the instructor's instructions.

   C. To add, hook one hose from refrigerant cylinder to bottom of service cylinder, crack liquid valve on cylinder allowing liquid to enter hose to service cylinder. Purge hose at bottom fitting to service cylinder. Now crack valve at top of service cylinder allowing pressure to drop which will allow the liquid from the refrigerant drum to go into the service cylinder. When the right amount has been reached cut the bottom valve off on the cylinder. Turn the knob from liquid to vapor, this will allow the liquid in the hose to go back into the tank while holding the hose above the refrigerant tank. Close off valve on refrigerant tank and bleed hose.

3. Have the instructor check the amount in the service cylinder.

4. Removing gas from the cylinder back into refrigerant drum can be done in several ways:

   A. By setting service cylinder higher than the drum and allowing gravity flow to transfer.

   B. By putting the refrigerant drum in a freezer, then hooking the service cylinder to the drum causing the liquid to flow to a cooler place.

   C. By applying heat to the service cylinder thereby forcing the liquid into the drum.

USE WHICHEVER METHOD YOUR INSTRUCTOR RECOMMENDS!

MAJOR BLOCK Refrigeration **NAME**

TASK Refrigerants

UNIT Installing and Using Access Valves **TIME (est.)** **(act.)**

UNIT NO. REF-12

OBJECTIVE(S)

Install and use at least two types of access (service) valves.

START ➔ W-1 ➔ W-2 ➔ A-1 ➔ W-3 ➔ C-1 ➔ L-1 ➔ C-2 ➔ L-2 ➔ C-3

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-12a
W-2 Text Assignment REF-12a
W-3 Assignment Sheet REF-12a
W-4
W-5
W-6
W-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-12a
L-2 Job Sheet REF-12b
L-3
L-4
L-5
L-6
L-7
L-8
L-9

AUDIOVISUAL(S)

A-1 Slide Set REF-12a
A-2
A-3
A-4
A-5
A-6
A-7

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4
C-5
C-6
C-7
C-8
C-9

Study the following terms and definitions:

1. Core Type Access Valves A valve that can not shut off flow of refrigerant through the line it is attached to, but does give access for reading pressures and installing refrigerant.

2. Cracking a Valve Slowly opening a valve one half to one full turn from a fully closed position.

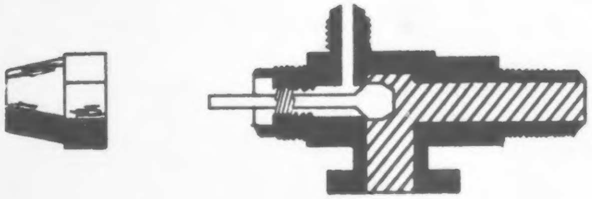
3. Line Tap Valve A temporary access valve installed on the process line so that it can be pinched off and soldered. If these valves are left on the system, they will eventually leak.

4. Process Tube A piece of tubing about 6 in. long usually on the compressor, but could also be in both the low and high side of the system. Its purpose is for attachment of several types of accessories valves such as Schrader valves, tap-a-line, and stub valves.

5. Service Valves or Access Valves These valves usually are installed in the system for service purposes. This valve is probably the most misused accessory in the refrigeration field.

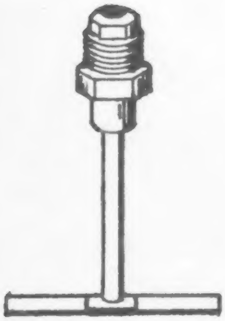
Identify the types of service valves shown and describe the function of each.

A. Function:



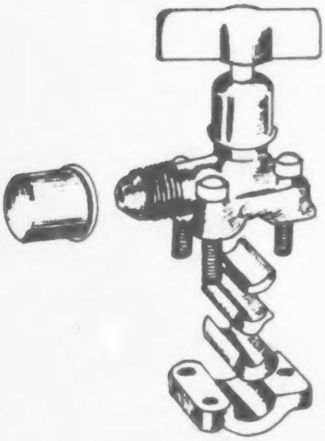
Type ______________________________

B. Function:



Type ______________________________

C. Function:



Type ______________________________

Use a stem type service valve using the tools, materials and procedures shown. Contact the instructor for the refrigeration system to be used and valve to be installed.

I. Tools and materials.

A. Refrigeration ratchet

B. Refrigeration gauge set

C. Open end wrench

D. SAFETY GLASSES

E. Oil can

F. Refrigeration system with stem type service valves

G. Clean shop towel

II. Procedure

A. PUT ON SAFETY GLASSES

B. Remove valve stem covers

C. Remove service port caps
(NOTE: If a pressure switch capillary tube is connected to the service port, back seat the valve stem before removing the flare nut.)

D. Clean around gauge ports

E. Attach gauge hoses

F. Check to be sure gauge manifold valves are closed to center port

G. Place two drops of oil on valve stems at the packing nut

H. Crack service valve stems

I. Purge hose at gauge manifold connection

J. Start system

K. Allow system pressures to stabilize

L. If high side gauge vibrates excessively, back seat the discharge service valve stem until vibration stops

M. Check pressure readings

N. Back seat service valves

O. Open refrigeration gauge set valves to release hose pressure

P. Remove gauge hoses
(NOTE: Gauge hoses should be plugged or placed on hose holder when not in use.)

Q. Replace service port caps and tighten
(NOTE: If pressure switches are connected to the valve service ports, the valve stems will have to be cracked during normal operation.)

R. Check valve stem packing nuts for leaks

S. If leak is indicated, tighten the packing nuts

T. Replace the valve stem caps

U. Clean up and put away tools

Install a soldered-on Schrader type service valve, using the tools, materials, and procedures shown. Contact the instructor for the refrigeration system and service valve to be used.

I. Tools and Materials

  A. Valve core tool

  B. Torch

  C. Striker

  D. Safety glasses

  E. Access core type service valve

  F. Silver alloy

  G. Sand cloth

  H. Silver brazing flux

  I. Clean damp shop towel

II. Procedure

  A. Put on safety glasses

  B. Clean area on tubing where valve is to be placed

  C. Remove the core from the valve

  D. Apply flux to the joint

  E. Light and adjust the torch

  F. Apply heat to the joint

  G. Apply the silver alloy

  H. Remove heat as soon as the alloy flows completely around the joint

  I. Turn off the torch

  J. Clean the joint with a clean, damp shop towel
  (NOTE: Be careful that moisture does not enter the refrigeration system while cleaning and cooling the braze joint.)

  K. Replace the core in the valve
  (NOTE: If this is a line piercing valve, use the manufacturer's recommended procedure for piercing the line.)

  L. Have the instructor inspect

  M. Clean up and put away tools

MAJOR BLOCK Refrigeration **NAME**

TASK Refrigerants

UNIT Maintaining and Understanding Manifold Gauges and Hose **TIME (est.)** **(act.)**

UNIT NO. REF-13

OBJECTIVE(S)

Calibrate a set of gauges at 0-PSIG and check against gas in a given tank by corresponding temperature to pressure.

START ➔ W-1 ▷ W-2 ▷ C-1 ▷ W-3 ▷ A-1 ▷ W-4 ▷ L-1 ▷ C-2 ▷ L-2 ▷ C-3 ▷

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-13a
W-2 Assignment Sheet REF-13a
W-3 Information Sheet REF-13b
W-4 Text Assignment REF-13a
W-5
W-6
W-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-13a
L-2 Job Sheet REF-13b
L-3
L-4
L-5
L-6
L-7
L-8
L-9

AUDIOVISUAL(S)

A-1 Slide Set REF-13a
A-2
A-3
A-4
A-5
A-6
A-7

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4
C-5
C-6
C-7
C-8
C-9

Most gauges used in refrigeration will be one of two types, the compound gauge or the high pressure gauge. The mechanics of operation are the same for both.

The compound gauge is calibrated to read pressure above and below atmospheric pressures. Its use is usually for reading the suction pressure of a system. Note that below 0 the reading is in mercury column inches and above 0, it is indicating PSIG. 29.92 inches of mercury is equal to 14.7 lbs. normal atmospheric pressure.

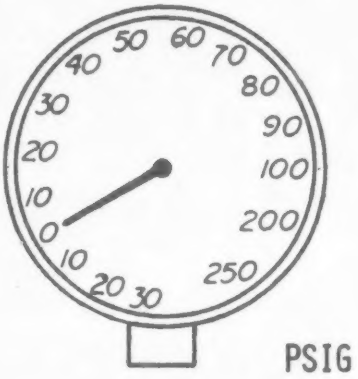


FIGURE A

The high pressure gauge is calibrated to start at atmospheric pressure, being 0, and going to 500 on most gauges. This gauge is usually used in reading the pressure in the high side of the system.

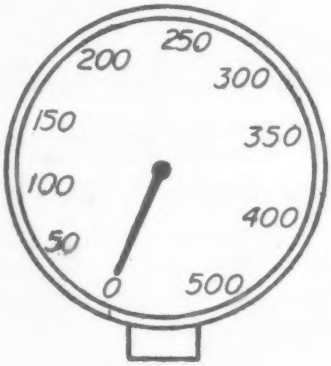


FIGURE B

Both the compound gauge and the high pressure gauge can be bought with a scale calibrated to the corresponding temperature chart. These calibrated gauges show the temperature of the gas in the system for each pressure level on the gauge for all gases. These temperature scales give a good estimate of the gas temperature but not an exact reading. In any situation which requires accuracy, the service technician must use the temperature to pressure chart.

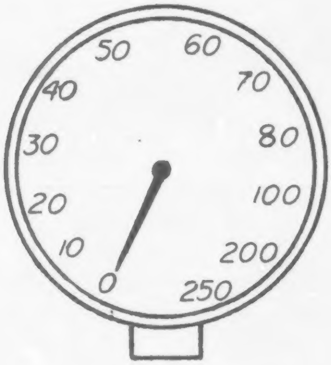


FIGURE C

The inner parts of the gauge are usually constructed of brass. There is a 1/8" pipe threaded fitting with an opening going to what is known as a bourdon tube. This tube is connected to a gear assembly which controls the turning of the dial. The dial is calibrated to read 0 at atmospheric pressure. The bourdon tube responds to the atmospheric pressure on the outside of the tube and to the pressure applied through the fitting to the inside. Its accuracy is very poor in the vacuum scale, but is more accurate in the middle range on the scale. Both the compound gauge and the high pressure gauge give more accurate readings inthe middle ranges of the scales and less accurate readings on the high and low ends of the scales.

In gauge readings, the technician needs not only to be able to read the gauge, but also to understand what it is telling.

The compound gauge is giving the pressure reading where it is installed, but, the most important thing to determine is the temperature at which any liquid is boiling in the evaporator or low side.

The high pressure installed or hooked up to the high side of a system is not only giving the pressure where it is hooked up, but most important of all, it is giving the temperature at which the vapor leaving the compressor is condensing. This is done by the corresponding temperature to pressure chart (better known as the saturation chart).

After inserting the pressure under each gauge, convert the pressure to temperature by using the saturation chart for the right gas. These are for suction pressure reading.

F-12 GAS

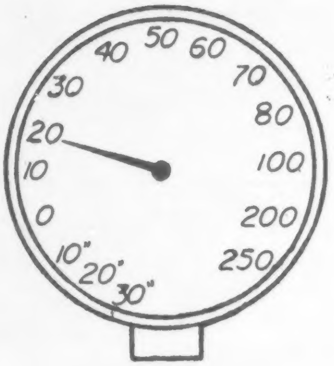


FIGURE D-1

Suction Pr. ________

Boiling Temp. ______

F-12 GAS

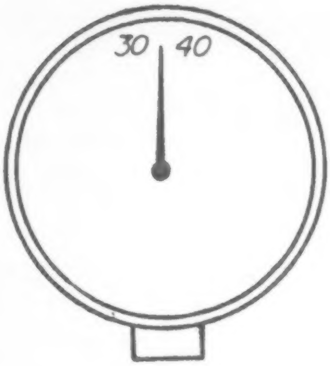


FIGURE D-2

Suction Pr. ________

Boiling Temp. ______

F-12 GAS

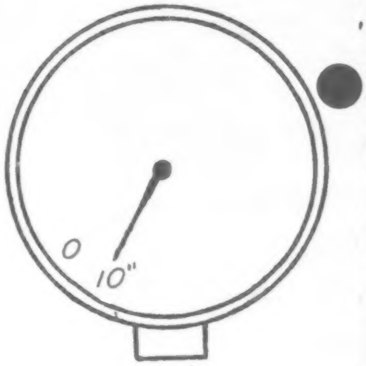
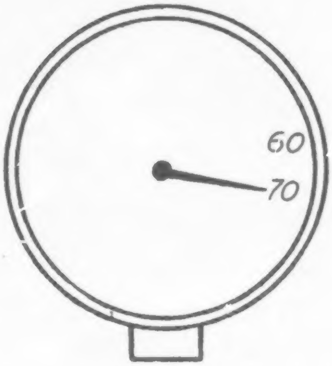


FIGURE D-3

Suction Pr. ________

Boiling Temp. ______

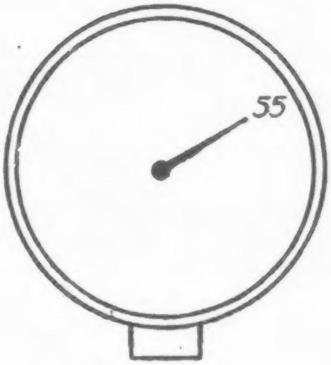


F-22 GAS

FIGURE D-4

Suction Pr. __________

Boiling Temp. _______

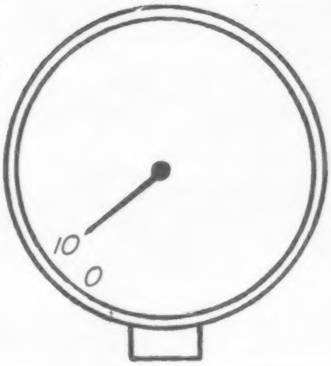


F-22 GAS

FIGURE D-5

Suction Pr. __________

Boiling Temp. ________



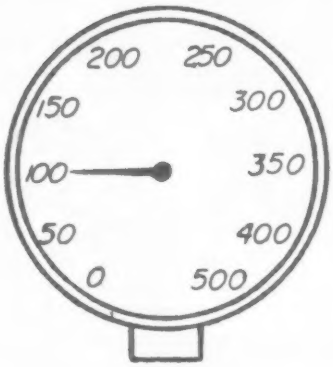
F-502 GAS

FIGURE D-6

Suction Pr. __________

Boiling Temp. __________

Mark the pressure of each reading below, plus convert it to temperature by using your saturation chart. These 6 are for discharge pressures.

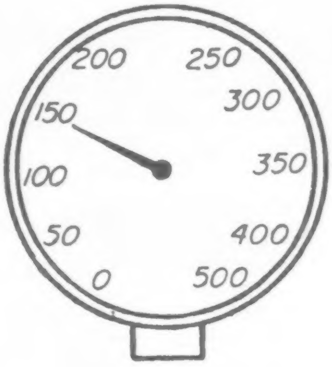


F-12 GAS

FIGURE E-1

Discharge Pr. __________

Condensing Temp. _____

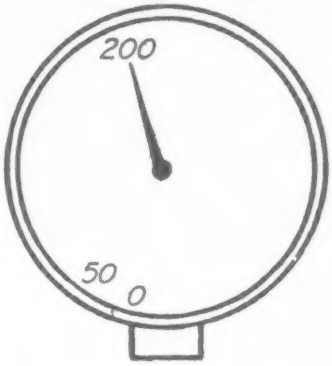


F-12 GAS

FIGURE E-2

Discharge Pr. __________

Condensing Temp. ______



F-22 GAS

FIGURE E-3

Discharge Pr. __________

Condensing Temp. ______

F-22 GAS

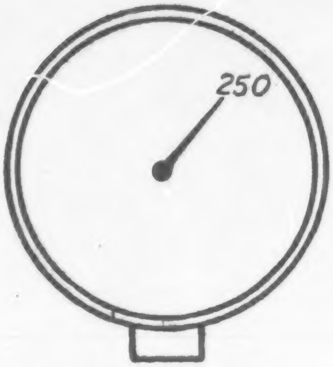


FIGURE E-4

Discharge Pr. __________

Condensing Temp. _______

F-502 GAS

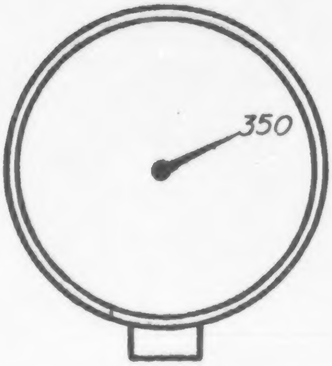


FIGURE E-5

Discharge Pr. __________

Condensing Temp. _______

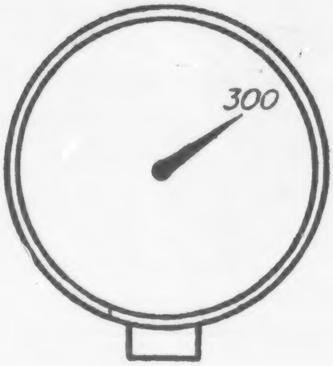


FIGURE E-6

Discharge Pr. __________

Condensing Temp. _______

Most manifolds are set up with 2 gauges on them. The compound gauge is usually on the left and the high pressure gauge is usually on the right, but they could be either way. Gauges must be checked regularly. They are easy to knock out of calibration. One of the better ways of checking is with a tank of freon. By using the temperature to pressure conversion chart, the ambient temperature of the freon can be converted to pressure and checked against the gauge reading when the gauge is coupled to the freon.

Manifolds can be used for several things but there are three main functions:

1. Reading suction pressure.
2. Reading head or discharge pressure.
3. Putting anything in the system or taking anything out.

To read suction pressure or discharge pressure, both valves must be closed. Neither valve should ever be open unless something is being put into or taken out of the system, then, the only valve that should be open is the one through which something is being put into or taken out of the system. When both valves are closed, the pressure of the low side will show up on the compound gauge, and the high side pressure on the high side gauge, as shown in Figure F.

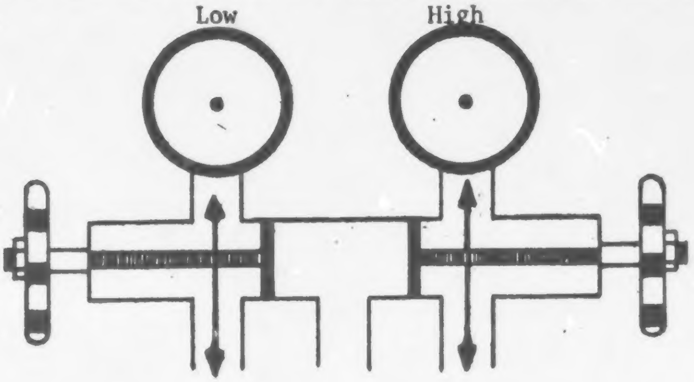


FIGURE F

In Figure G, the low side or suction valve has been opened to put something into or take it out of the suction side through the center connection hose. The high side valve remains closed.

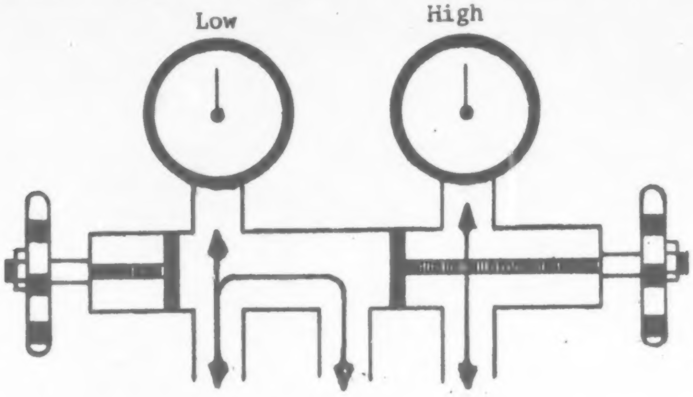


FIGURE G

In Figure H, the high side valve has been opened to put something in or take it out of the high side. The low side valve remains closed.

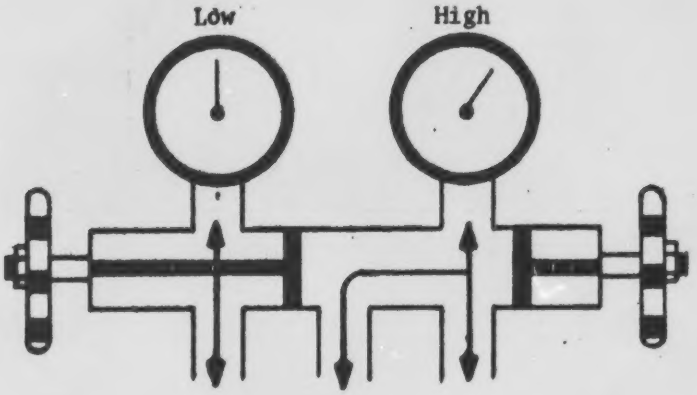


FIGURE H

In Figure I, both valves have been opened to put something in or take something out of both sides of the system at the same time through the center hose.

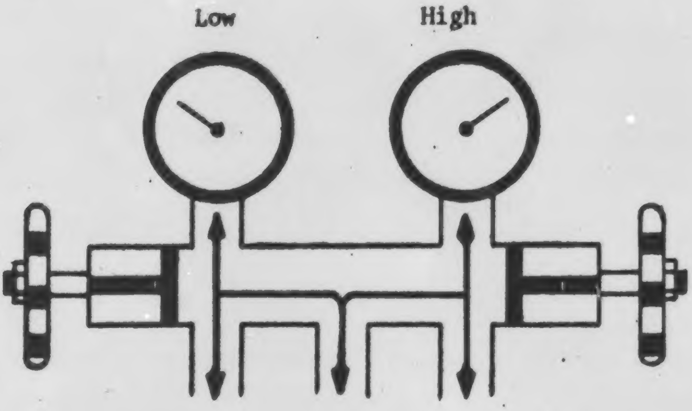


FIGURE I

Service Valves Inspection

1. Equipment needed:

   One kit of miscellaneous pressure gauges and valves.

2. Procedure:

   a. Study the gauges, noting their differences.
   b. Dismantle the service valves in the kit.
      1. Do not mix up the parts.
      2. Have the instructor check the dismantled valves.
      3. Study the parts.
   c. Ascertain what cracking a valve means.
   d. Determine why the fixed end of the refrigeration wrench is always used.
   e. Assemble the valves.
   f. Clean up the station and tools, then return all the material to the tool room.

Gauge Manifold Instructions

1. Equipment needed:

   One kit consisting of manifold gauges and hose.

2. Tools needed:

   One gauge manifold complete with gauges.

3. Procedure:

   a. Study the manifold gauge and hose.
   b. Calibrate both gauges at 0.
      1. You will be required to demonstrate and verbally give, the step-by-step procedures on the correct way to zero gauges on the manifold.
      2. You will be required to demonstrate and verbally give, the the step-by-step procedure on the short method.
   d. Check and calibrate gauges on a tank of gas for which pressure is known.

CAUTION: WEAR GOGGLES WHEN WORKING AROUND PRESSURE!

MAJOR BLOCK Refrigeration **NAME** REF-14

TASK Refrigerants

UNIT Installing and using refrigeration manifold gauges **TIME (est.)** ______ **(act.)** ______

UNIT NO. REF-14

OBJECTIVE(S) Install and use refrigeration manifold gauges.

START ➔ W-1 W-2 W-3 A-1 W-4 L-1 C-1

WRITTEN ASSIGNMENT(S)

W-1 Text Assignment REF-14a
W-2 Assignment Sheet REF-14a
W-3 Information Sheet REF-14a
W-4 Information Sheet REF-14b
W-5 ______
W-6 ______
W-7 ______

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-14a
L-2 ______
L-3 ______
L-4 ______
L-5 ______
L-6 ______
L-7 ______
L-8 ______
L-9 ______

AUDIOVISUAL(S)

A-1 Slide Set REF-14a
A-2 ______
A-3 ______
A-4 ______
A-5 ______
A-6 ______
A-7 ______

CHECKPOINT(S)

C-1 See Instructor
C-2 ______
C-3 ______
C-4 ______
C-5 ______
C-6 ______
C-7 ______
C-8 ______
C-9 ______

Using the preceeding text assignment answer the following questions.

1. What is meant by purging?

2. When cracking valves which end of the service valve should you use?

3. Why plug openings after removing any part of refrigeration system?

4. What does the term cracking mean?

5. What precaution should you take when discharging a system?

6. What is the purpose of the manual valves installed in a mechanical refrigeration system?

7. Explain back seat and front seated valves.

8. What is the difference between a one-way service valve and a two-way service valve?

9. Explain how you can convert manifold pressure reading to temperature.

10. What is a suction service valve?

11. What is a liquid receiver service valve?

12. What should be the first thing you should do after hooking up hose to unit, before allowing anything in or out of the system?

13. What are the three things to be noted which will assure good service and valve life?

Study the following terms and definitions.

1. Suction service valve -- A two way manually operated valve used to control suction gas flow to the compressor and for servicing the unit.

2. Discharge service valves -- Two way valves that provide a cut-off between the compressor and condensor, also used for servicing high side of unit.

3. Liquid receiver service valve -- A two or three way manual valve used for installation and service purposes, used to stop the flow of the liquid to the evaporator, which when closed will cause compressor to pump all gas to the high side of the system.

4. King valve -- Same as the liquid receiver service valve, called a king valve because it is a master valve. When closed the gas can be pumped out of the low side, at this point any part can be replaced in the low side.

5. Oil equalizing line -- A line running from one compressor oil pan to another to assure equal oil level in all compressors. Could be from one to another or several.

6. Suction equalizing line -- The line running from one compressor crankcase to another crankcase. Which will allow the same suction pressure in all compressors.

7. Manifold gauges and hoses -- Tools that the refrigeration technician uses to check low and high-side pressures, charge and discharge a system. Check pressure, add oil, bypass the compressor, unload gauge lines of high pressure liquid and vapor as well as perform many other operations without replacing regular gauges.

8. Corresponding temperature to pressure chart -- A table that shows the pressure/temperature relationship of a liquid under saturated conditions.

9. Condensing temperature -- The temperature inside a condenser at which refrigerant vapor gives up its latent heat of vaporization and becomes a liquid. This varies with the pressure.

10. Boiling temperature -- The temperature at which a fluid changes from a liquid to a gas. The boiling tempeature for any liquid is controlled by the pressure placed upon it. If the pressure is increased the boiling temperature is raised, if the pressure is lowered the boiling temperature will be lowered.

11. Super heat -- The temperature of vapor above its boiling temprature. It is heat added after all liquid has boiled out.

12. Subcooled -- Cooling of a liquid below its condensing temperature.

13. T.D. -- Difference in temperature at the two ends of the circuit, necessary for heat transfer. (temperature drop).

14. Pressure drop -- The pressure difference at the two ends of the circuit.

15. Back case pressure regulator -- A valve which will hold back a predetermined pressure in the evaporator which can be used to maintain an evaporating temperature.

16. Crank case pressure regulator -- Modulates suction pressure to compressor intake to provide overload protection for compressor.

17. Ambient temperature -- Temperature surrounding an object on all sides.

The service valve provides a means of checking the high and low side pressures, adding refrigerant, letting out refrigerant, purging off non-condensibles gases, and adding oil.

The valves can be used to check pressure drop across any given piece of equipment.

It could be said that there are only three real uses for service valves. Low side service, high side service, and liquid line service. All of these valves could be made the same way and look the same (See Figure A) but a good rule to go by is that the suction service valve is usually the largest valve on the compressor with the largest line coming to it. The discharge service valve is the smallest of the two valves. The liquid service valve is located on the line leaving the liquid receiver.

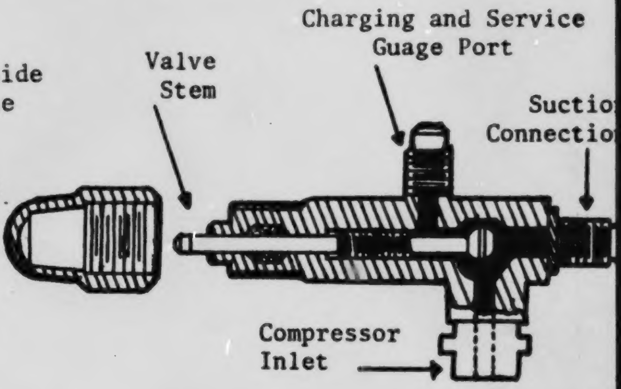
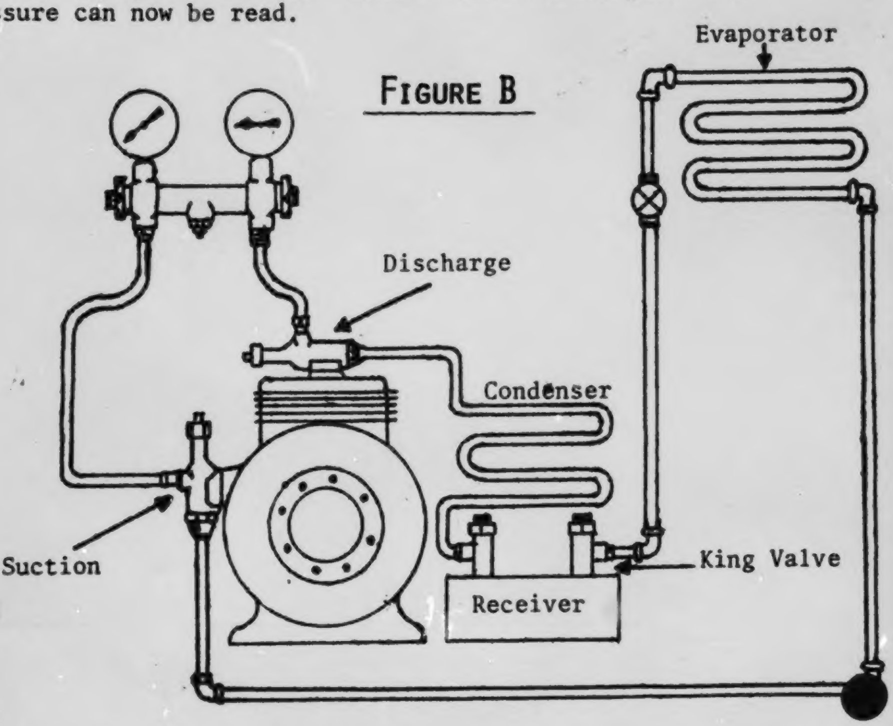


FIGURE A

Now look at how gauges are used to service a system. Hook the left hand hose to the suction line service port and the right hand hose to the discharge service valve port as shown in Figure B. The center must be plugged, if only reading pressures, or hooked to a drum if servicing is required. Both manifold gauges should be closed. The suction pressure and the discharge pressure can now be read.

After looking at and studying service valves for some of the larger units Schrader valves, piercing valves, and saddle valves need to be reviewed. These come in many different makes but their primary purpose is to give easy access to a sealed refrigeration system. Most technicians feel that these valves are over used. Some are installed and left on the units resulting in a leak. The technician should only place these types of valves in positions where they can easily be removed.

FIGURE B



Using the Manifold and Gauges

1. Equipment:

   A. Inoperative open type compressor with services.
   B. Operating open type refrigerating systems.

2. Tools:

   1 Gauge manifold complete with gauges.
   1 ratchet wrench 1/4 inch drive and various other tools needed.

3. Install and remove the gauge manifold on an inoperative compressor.

   CAUTION: Wear goggles on any system that is charged with refrigerant.

   1. Install and remove gauges
   2. You will be required to demonstrate and verbally give the step-by-step procedures on the correct way to install gauges on the system.

4. Install and remove gauges on an operating system.

   Fill out "Data Sheet A" as this job is being done.

   1. Instructor will assign unit(s).
   2. Caution: Wear goggles.
   3. Turn off refrigerant system.

5. Remove valve seal caps from Discharge Service Valve (DSV), and Suction Service Valve (SSV).

6. Loosen both service valve packing glands 1/4 turn.

7. Check to make sure service valves are back seated.

8. Remove caps from gauge connections on service valves.

9. Install both DSV hose and SSV hose, tighten both.

10. Use rigid end of wrench and crack both DSV and SSV 1/4 to 1 turn.

11. Crack SSV and DSV at manifold and purge air out of hose.

12. Start unit. You should now be able to read both discharge pressure and suction pressure.

DATA SHEET A

UNIT I:

Type Refrigerant ______________________ Evaporator Type ____________

Condenser Type ______________________ Compressor Type ____________

High Side Pressure Reading. (Operating) __________ (Off) ____________

Low Side Pressure Reading. (Operating) __________ (Off) ____________

Comments: ____

____

____

____

Boiling Temperature in Evap. ____________ Condensing Temp. __________

UNIT II:

Type Refrigerant ______________________ Evaporator Type ____________

Condenser Type ______________________ Compressor Type ____________

High Side Pressure Reading. (Operating) __________ (Off) ____________

Low Side Pressure Reading. (Operating) __________ (Off) ____________

Comments: ____

____

____

____

____

Boiling Temp. in Evaporator ____________ Condensing Temp. __________

MAJOR BLOCK Refrigeration **NAME**

TASK Refrigerants

UNIT Using a Vacuum Pump **TIME (est.)** **(act.)**

UNIT NO REF-15

OBJECTIVE(S)

Use the vacuum pump to evacuate a refrigeration system.

START ➡ W-1 W-2 W-3 W-4 C-1 W-5 A-1

L-1 C-2 L-2 C-3 W-6 C-4

WRITTEN ASSIGNMENT(S)		**AUDIOVISUAL(S)**	
W-1	Information Sheet REF-15a	**A-1**	Slide/Tape REF-15a
W-2	Text Assignment Sheet REF-15b	**A-2**	
W-3	Information Sheet REF-15b	**A-3**	
W-4	Assignment Sheet REF-15a	**A-4**	
W-5	Information Sheet REF-15c	**A-5**	
W-6	Assignment Sheet REF-15b	**A-6**	
W-7		**A-7**	
LABORATORY ASSIGNMENT(S)		**CHECKPOINT(S)**	
L-1	Job Sheet REF-15a	**C-1**	Instructor Check
L-2	Job Sheet REF-15b	**C-2**	Instructor Check
L-3		**C-3**	Instructor Check
L-4		**C-4**	Instructor Check
L-5		**C-5**	
L-6		**C-6**	
L-7		**C-7**	
L-8		**C-8**	
L-9		**C-9**	

EVACUATION

A. Terms and definitions

1. Absolute pressure - Gauge pressure plus the atmospheric pressure of 14.7 p.s.i.

2. Vacuum pump oil - Nonfoaming, nonadditive oil designed for use in vacuum pumps.

3. Mercury manometer - Pressure measuring instrument consisting of a "U" shaped glass tube and mercury.

4. Noncondensables - Substances that remain in a gaseous form in a refrigeration system, such as nitrogen and oxygen.

5. Low vacuum - Vacuum of 2,000 microns or more, obtainable with a single stage pump.

6. High vacuum - Vacuum of 2,000 to .1 microns, requiring a two stage pump.

7. Single stage pump - Discharges directly into the atmosphere and is capable of pulling down to 1,000 microns.

8. Two stage pump - Discharges into a second vacuum and is capable of pulling down to .1 microns.

9. Micron - Unit of pressure measurement in thousandths of millimeters of mercury.

10. Evacuation - Removal of air and moisture from a refrigeration system

11. Vacuum - Pressures below the atmospheric pressure of 14.7 p.s.i., indicated by inches of mercury ("HG) on a 0 to 30" scale.

B. Reasons for evacuating a refrigeration system,

1. To remove noncondensables from the system
2. To remove oil trapped refrigerant
3. To remove moisture from the system

C. Effects of moisture in a refrigeration system,

1. Combined with refrigerant oil and heat, it creates sludge
2. Causes deterioration of metal parts inside the refrigeration system

3. Combined with halogen type refrigerants it creates hydrochloric and hydroflouric acid.
4. Ice crystals will form at expansion point stopping refrigerant flow.

D. Effects of air in a refrigeration system

1. Increases the discharge pressure.
2. Noncondensables combined with moisture will accelerate the formation of corrosion, acid, copperplating, and sludge.
3. Will take up space in condenser.

E. Effects of ambient temperature on proper evacuation

1. Increasing the ambient temperature will decrease evacuation time, try to have all component parts at the same temperature.
2. Moisture is removed in vapor state.
3. Boiling temperature decreases as the pressure decreases.

F. Low and high vacuum pumps

1. Generally of the compressor type.
2. Rated at 1 cubic foot per minute (c.f.m.) or less.
3. Single stage.

G. Care of vacuum pumps

1. Change oil after every extensive evacuation.
2. Keep pump clean.
3. Keep caps on the inlet and outlet ports.
4. Check to see if the pump will pull a vacuum on itself.
5. Do not discharge refrigerant through the vacuum pump.
6. Do not operate vacuum pump with a low oil level.

H. Types of vacuum indicators

A. Compound gauge

1. Used in conjunction with other vacuum indicators.
2. Accurate to 25" HG.

Pressure Measurement

The air conditioning and refrigeration mechanic must have a means for determining the condition (wet or dry) of a closed refrigeration system. To understand the concept of measuring the amount of pressure in a system, one should first look at the measurement of air pressure (atmospheric pressure) on the earth's surface.

The earth's atmosphere extends 50 miles upward from the surface of the earth. Imagine a one inch square column of air extending from sea level to the outer limits of the atmosphere. That column of air would weigh an estimated 14.7 lbs. Since the word force also means the weight of something and pressure means unit(s) of force per square inch (psi) then the weight of the column of air can be called the atmospheric pressure which at sea level is 14.7 psi. Theoretically weather conditions must be "standard" to obtain 14.7 psi, of course a reading in a valley would be more and on a mountain would be less. This fact should be considered when a mechanic sets controls for use a high altitudes. Generally, under standard conditions, 14.7 psi is used in most refrigeration work. Since this pressure measurement is based upon absolute zero, the 14.7 psi may be called an absolute pressure.

The above information is handy to know when the refrigeration mechanic is faced with computing gauge pressures to absolute pressures. Often refrigeration tables give pressures in absolute values. The conversion from gauge pressures to absolute pressures is easy. Simply add 14.7, the atmospheric pressure, to whatever the guage is. The sum will represent the absolute pressure of the system which may then be compared to the refrigeration charts.

Inches of Mercury Measurement

Atmospheric pressure may be illustrated with a simple barometer. Most barometers which are found in households use mercury (hg is the symbol for mercury) as a measuring device. However, a barometer could use other liquids such as water to measure atmospheric pressure. Consider this simple fact which is often discovered by youngsters washing dishes in a kitchen sink. When a drinking glass is submerged, therefore completely full of water, and is gradually picked up, bottom first, to and above the surface of the water; the glass will continue to remain full. This occurs even though the base of the glass and most of the sides of the glass are completely out of the water. The glass will remain full until the rim breaks the surface plane of the water. Of course it is not practical, but this same experiment will work on a much larger scale with a glass (or tube) 34 feet high (33.9 to be exact). Atmospheric pressure on the surface of the water in the sink is what keeps the water form pouring out of the glass.

This same little trick will work with a tube of mercury and a suitable container also filled with mercury. In this instance, however, the mercury will only stand 29.92 inches high. This is considerably less than water due to the heavy weight of mercury. For a similar reason, mercury is used in barometers instead of water.

This explanation is given for the derivation of atmospheric pressure in terms of inches of mercury so that pressure measurement below the standard atmospheric pressure may be more clearly understood. In addition, instruments measuring vacuum are calibrated in inches of mercury

High efficiency and low maintenance in the modern refrigeration system can be insured by making certain thorough evacuation procedures are followed. Two things can be determined by pulling a vacuum on an air conditioning system. First, it will be determined whether the system has a leak. Second, if moisture and non-condensables exist in the system, they can be identified and removed. Non-condensables are those undesirable gases such as air, clorine and combinations of oxygen, hydrogen and nitrogen which have built up in the system as a result of mixing with refrigeration oils. These problems will show up in the refrigeration system when it becomes difficult to vacuum. Problems also arise when the vacuum cannot be held for a long period of time. If a vacuum can be held for as long as twelve (12) hours, it may be considered sound.

Non-condensables present in the system can cause much damage. Oxygen is one of nature's most chemically active elements. Its rate of chemical reaction with the refrigeration oil increases very rapidly with a rise in temperature above 200°F.

It has been proven that with every 18°F rise in temperature above 200°F, the rate of chemical reaction of oil with the oxygen doubles when this occurs, the oil starts to break down and deposits build up in the discharge valve area. Valves in the compressor stick or leak creating high velocities and restricted flow. This results in temperature increases high enough to start a chemical reaction with a break down of the refrigerant. Further, this creates an acid condition which causes the biggest percentage of burn outs in hermetic compressors.

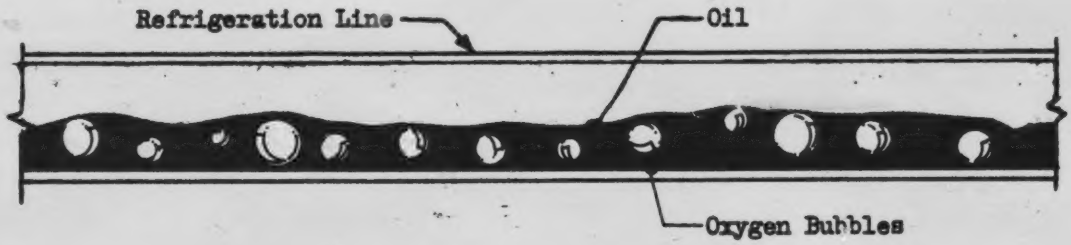


FIGURE A

Another of the more formidable problems found in a refrigeration system is caused by water. A single drop of water can cause a major blockage of the refrigerant flow within a system. Water will cause a breakdown of the refrigerant oils and the refrigerant used in a system. This makes moisture the greatest of all enemies to the inside of the refrigeration system, especially units equipped with hermetic compressors. The following are the primary ill effects of moisture in the system:

1. Freeze up at the expansion valve or metering device.
2. Corrosion of metals which causes sludge.
3. Flapper-valve failure.
4. Copper plating.
5. Chemical damages to insulation, etc.

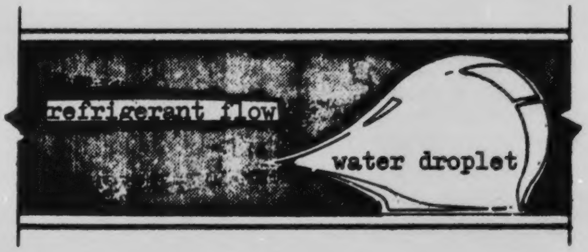


FIGURE B

A freeze up at the expansion valve is caused when small droplets of water freeze and form ice crystals. This occurs whenever the system temperature drops below the water's freezing point. A freeze up such as described here does not occur in ammonia based systems (due to the chemical make up of the refrigerant); it is, however, a real problem in most other types of systems commonly used.

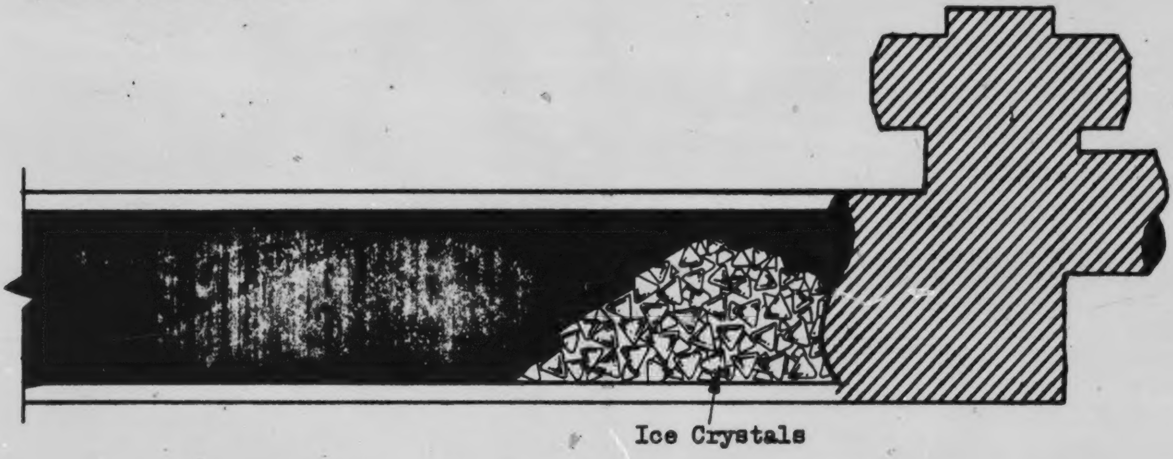


FIGURE C

In a properly vacuumed and charged system, corrosion should not be a problem. Unfortunately it is impossible to get all the air out of a system and occasionally moisture does get in. In our environment, when metal comes in contact with moisture and air, corrosion occurs. This same thing happens inside the refrigeration system when moisture is present; corrosion starts eating away on the metal.

Moisture when teamed with refrigerant in the refrigeration system will create acid. Acid in the system can cause a burn out when a hermetically sealed motor is used. When heat is added to moisture and refrigerant, even more acid is created. As a result, when the temperature is increased the corrosive process is speeded up, therefore increasing the likelihood of a compressor burn out.

Moisture + Refrigerant = Acid

Moisture in a refrigeration system tends to have some peculiar traits. It will "lay lazy" in a warmer section of the system until an atmospheric temperature change occurs. It will then start moving and will mix with the oil and refrigerant and will naturally spread throughout the system cuasing damage. This is why a system will work for long periods of time without a flaw and all at once stop because of some blockage.

Once the moisture starts moving with the refrigerant and oil in the refrigeration system it will freeze up the metering devices. It also could freeze "open" any moving parts causing the metering device to flood the evaporator. This mishap usually occurs on the valve parts.

Assignment Sheet REF-15a

Match the type of vacuum pumps which should be used to the following situations or conditions.

Conditions - Situations

_____ A. Moisture in system

_____ B. Oxygen in system

_____ C. Deep evacuation

_____ D. Non-condensables in system

_____ E. Triple evacuation

_____ F. Acid formed in system

_____ G. Multiple evacuation

_____ H. To reach 500 microns pressure

_____ I. To reach .1 microns pressure

_____ J. Most inefficient

_____ K. Most efficient

_____ L. Water in the system

Vacuum Pumps

1. Single-stage
2. Two-stage
3. Reciprocal

Vacuum Pumps

The refrigeration mechanic has a choice of several types of vacuum pumps. A mechanic must make several considerations when choosing the correct one.

First it must be sized correctly for the needs of the job. Things to consider are:

1. Time requirements for completion of the job.
2. Speed of the pump (in CFM).
3. Size of the system to be vacuumed in CFM.
4. Ambient temperature present.
5. Internal restrictions in the refrigeration system.
6. Size of fittings, hoses and connections.

A vacuum pump is designed to remove all moisture from a hermetic refrigeration system. The vacuum pump does not actually remove water from the system. Rather, it changes the moisture to a vapor and removes it. This is accomplished by lowering the system pressure to reduce the boiling point of water.

There are three basic types of pumps. The Two-Stage High Vacuum Pump is the most efficient of these types. Under laboratory conditions it is possible for a two stage vacuum pump to pull an extremely low .1 microns. For prolonged periods of time 50 microns is possible. Even more efficient but still within the two stage pump category is a high capacity vacuum pump.

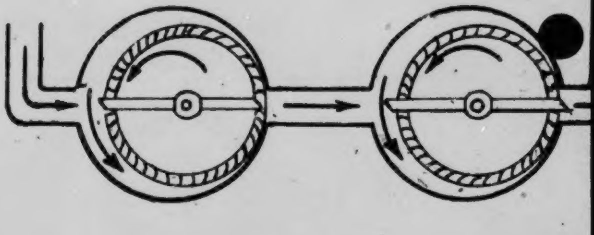


FIGURE D

A Single Stage Vacuum Pump will not pull a vacuum down nearly as low as a two stage pump. In addition, the system oil becomes contaminated much faster. The single stage pump is generally not recommended for efficient service work. A third type, the Reciprocal Pump is the most inefficient of all. It should be used only in emergency cases.

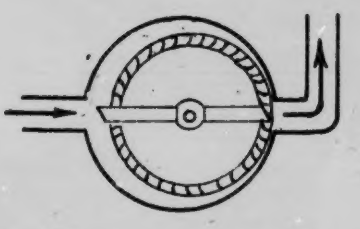


FIGURE E

Vacuum Pump Oil

It is possible for the refrigeration system to pull the oil and any contamination out of the vacuum pump when it stops. For this reason it is important to have a vacuum tight hand valve between the system and the vacuum pump. This will permit the service-person to stop the pump and check the vacuum on the system. When the pump is running the vacuum reading obtained will be that of the pump and not of the entire system, because of restrictions in the hoses and the system.

Vacuum oil is a much more refined oil than refrigeration oil. Using the correct oil in the system will help avoid problems in the future. Vacuum pump oil is dryer than refrigeration oil and will pick up moisture faster. Also, vacuum pump oil should be purchased in small containers, because it should be changed regularly.

Gauges

Of all measurements made by refrigeration metering devices, the thermocouple vacuum gauge and meter gives the most accurate readings. On it, however, the sensing tube is subject to becoming contaminated by dirt and other foreign debris and must be cleaned. To avoid problems the inlet opening to the sensing element must be plugged when it is not in use. Always check to see that the pump is functioning properly. A thermocouple with meter should help to determine if the water is being boiled out of the system. Otherwise a bad pump or loose connections will result only in degassing [removing non-condensable vapors (refrigerants)] the system.

New manifold gauges and hoses are not always leak proof. Most new hoses will leak when put under high pressure. This condition shows up quickly when they are placed under water. To insure that hoses and manifold gauges do not leak a deep vacuum type hose should be used. Otherwise time will be wasted doing more than removing non-condensables from the refrigeration system. The best and most expensive vacuum pumps will not function properly without a perfect connection to the unit.

Multiple Evacuation

The instructor will assign a refrigeration unit on which "triple evacuation" can be performed. If additional review is needed refer to Slide Set REF-15a. Use a single-stage vacuum pump and the following procedures to evacuate the system until 28-in. mercury is reached on the compound gauge.

Procedures:

1. Install manifold gauge (the center hose should be connected to the vacuum manifold valves).
2. Open pump valve and close the refrigerant cylinder valve.
3. Manifold gauge valves should be wide open and service valves only half open.
4. Engage the pump and evacuate the system to 28 in. mercury vacuum. This reading must be determined from the compound gauge. Fifteen minutes should be sufficient time to reach this stage, then turn the pump off.
5. Release the refrigerant until 2 psig is reached and shut off the valve. The refrigerant should remain in the system for five (5) minutes collecting moisture.
6. Repeat the preceding procedure two more times. On the third evacuation, break the vacuum and charge to 10 psig or to the level recommended by the manufacturer.

Deep Vacuum

The instructor will assign a refrigeration unit on which a "deep vacuum" should be done. A two-stage vacuum pump should be used to remove air and water from the refrigeration system. Evacuate the system to at least 500 microns. An electronic vacuum indicator may be used to determine the level of evacuation.

Procedure:

1. Install manifold gauges.
2. Close the valve to the refrigerant cylinder and open valves to the pump and indicator.
3. Open the valves of the manifold gauges and open equipment service valves halfway.
4. Engage the pump and evacuate to 500 microns.
5. Shut off the pump valves for five (5) minutes to determine if the system will hold 500 microns. Check to see that all fittings are tight and that no leakage is occurring. If the vacuum does not hold the evacuation procedure should be repeated.
6. Close the valve to the indicator and release refrigerant into the system. Shut off the refrigerant valve when pressure has reached 10 psig.

Answer the following questions:

1. Match the terms on the right to the correct definitions.

_____a. Removal of air and moisture from a refrigeration system

_____b. Pressure measuring instrument consisting of a "U" shaped glass tube and mercury

_____c. Nonfoaming, nonadditive oil designed for use in vacuum pumps

_____d. Vacuum of 2,000 microns or more, obtainable with a single stage pump

_____e. Substances that remain in a gaseous form in a refrigeration system, such as nitrogen and oxygen

_____f. Discharges into a second vacuum and is capable of pulling down to .1 microns

_____g. Pressure below the atmospheric pressure of 14.7 p.s.i., indicated by inches of mercury ("Hg) on a 0 to 30" scale

_____h. Vacuum of 2,000 to .1 microns, requiring a two stage pump

_____i. Unit of pressure measurement in thousandths of millimeters of mercury

_____j. Discharges directly into the atmosphere and is capable of pulling down to 1,000 microns

_____k. Gauge pressure plus the atmospheric pressure of 14.7 p.s.i.

1. Vacuum pump oil
2. Micron
3. Evacuation
4. Noncondensables
5. High Vacuum
6. Vacuum
7. Single Stage pump
8. Mercury manometer
9. Low vacuum
10. Two stage pump
11. Absolute pressure

2. List three reasons for evacuating a refrigeration system.

   a.

   b.

   c.

3. Select the effects of moisture in a refrigeration system by placing an "X" in the appropriate blank.

   _____a. Floods the bowl float

   _____b. Combined with refrigerant oil and heat, it creates sludge

   _____c. Causes deterioration of metal parts inside the refrigeration system

   _____d. Dilutes the refrigerant

   _____e. Ice crystals will form at expansion point stopping refrigerant flow

   _____f. Makes sloshing noise in compressor

   _____g. Combined with halogen type refrigerants it creates hydrochloric and hydrofluoric acid

4. Select the effects of air in a refrigeration system by placing an "X" in the appropriate blank.

   _____a. Aids in the cooling of valves

   _____b. Noncondensables combined with moisture will accelerate the formation of corrosion, acid, copperplating, and sludge

   _____c. Will take up space in condenser

   _____d. Causes bubbles in sight glass

   _____e. Increases the discharge pressure

5. Describe the effects ambient temperature has on proper evacuation.

6. Distinguish between low and high vacuum pumps by placing an "L" next to the characteristics for a low vacuum pump and an "H" next to the charactersitics for a high vacuum pump.

_____a. Single stage or two stage

_____b. Generally of the compressor type

_____c. Single stage

7. List six steps in the care of vacuum pumps.

8. Describe the three types of vacuum indicators.

a. Compound gauge

b. Mercury manometer

c. Electronic vacuum gauge

MAJOR BLOCK Refrigeration **NAME**

TASK Refrigerants

UNIT Installing and Using Refrigeration Accessories **TIME (est.)** **(act.)**

UNIT NO. REF-16

OBJECTIVE(S)

Install at least two in-line accessories according to manufacturers specifications. (Filter driers, liquid indicators, etc.)

START ➔ W-1 W-2 W-3 C-1 W-4 W-5 A-1
W-6 C-2 L-1 C-3 L-2 C-4 L-3 C-5

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-16a
W-2 Text Assignment REF-16a
W-3 Assignment Sheet REF-16a
W-4 Information Sheet REF-16b
W-5 Text Assignment REF-16b
W-6 Assignment Sheet REF-16b
W-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-16a
L-2 Job Sheet REF-16b
L-3 Job Sheet REF-16c
L-4
L-5
L-6
L-7
L-8
L-9

AUDIOVISUAL(S)

A-1 Slide Set REF-16a
A-2
A-3
A-4
A-5
A-6
A-7

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 Instructor Check
C-5 Instructor Check
C-6
C-7
C-8
C-9

Information Sheet REF-16a

Study the following terms and definitions:

1. Absorb The ability of a substance to take up another substance.

2. Adsorb The ability of a substance to hold another substance.

3. Back Pressure Regulators A valve so designed that it controls a preset pressure behind it, and allows any pressure above this setting to pass through.

4. Crank Case Pressure Regulators A valve so designed that it will only allow a preset pressure in front of it. Known sometimes as a Front Pressure Regulator Valve.

5. Desiccant A substance which will hold a certain amount of moisture.

6. Drier Used to trap moisture by using a desiccant. Used mostly in the liquid line, but sometimes in the suction line.

7. King Valve or Liquid Line Valve A valve located in the liquid line usually at the liquid receiver outlet. Its name comes from its position being such that it cuts off all liquid passing through the receiver. This valve is operated manually and is used for pump down or servicing the system.

8. Liquid Indicator Allows a visual inspection of the refrigerant, liquid or vapor, as it passes through the system, usually a small sight glass mounted in the line.

9. Liquid Line Filter Drier This accessory is used to absorb moisture and to strain and hold any foreign matter. It also filters out waxes and acids that might be found in a system after it has been assembled or had a compressor burn out.

10. Moisture Indicator Usually a part of the liquid indicator which indicates any moisture content in the refrigerant.

11. Pump Down Valve When the king valve is operated with an electric solonoid, it is referred to as a pump down valve.

12. Receiver A storage tank for liquid refrigerant not being used in the system at any one particular time. Also used to store liquid refrigerant during pump down.

13. Suction Line Accumulator, or Boil Out Tank A device such as a tank used to trap any liquid from getting back to the compressor through the suction line.

14. Suction Line Filter-Drier Its main purpose is to clean and pick up any contamination in the suction line, before it gets to the compressor. Usually not found on new systems but used on some field built systems, it's biggest use is on systems where the compressor has had to be replace due to a burn out. Dirty filters can cause a restriction in the suction line.

15. Vibration Eliminator A flexible connection to decrease vibration, usually made of flexible copper or neoprene rubber.

A. Using the suggested reading in the textbooks as a reference, record the answers to the following questions. Constant referral may be required.

1. Define the use for a crank case heater.

2. State an installation where a crank case heater may be needed.

3. What problem might occur if a crank case heater isn't installed where needed?

B. Liquid and suction line filter and driers.

1. Moisture in a system creates both ________________ and ________________

2. Why should the system be kept clean and dry?

3. What are the two most common desiccants used in driers to pick up and hold the moisture? __________________ __________________

C. Heat Exchangers.

1. Why must care be exercised in the use of suction to liquid line heat exchangers?

2. List the two principle reasons for using heat exchangers.

3. Draw a rough sketch of a refrigeration system with a suction-liquid line heat exchanger in it. Include the compressor, condensor, evaporator and lines.

D. Mufflers.

1. What is the purpose of the muffler?

2. Where is the muffler installed in the system?

E. Accumulators.

1. What is the purpose of the accumulator?

2. Where should the accumulator be installed?

3. Why must provisions be made to return oil trapped by the accumulator?

F. Receivers.

1. Two common types of receivers are the __________________ and the __________________.

2. What is the purpose of the receiver?

3. What type of refrigerant systems do not use receivers?

Pump Down

This is a term in refrigeration used to describe the liquid line valve when it is closed, manually or electrically, causing all of the gas to be pumped and trapped in the high side of the system. This traps the refrigerant because the gas can not get back through the head valves of the compressor. The line-valve used to manually pump down the system is usually located in the liquid line, close to the receiver. It is either called the liquid line valve or it is sometimes referred to as the King-Valve. (See Figure A)

When a system is pumped down by the compressor, the refrigerant is stored in the condenser and the receiver. The low pressure switch is usually the controlling device which switches the compressor off or it can be controlled manually.

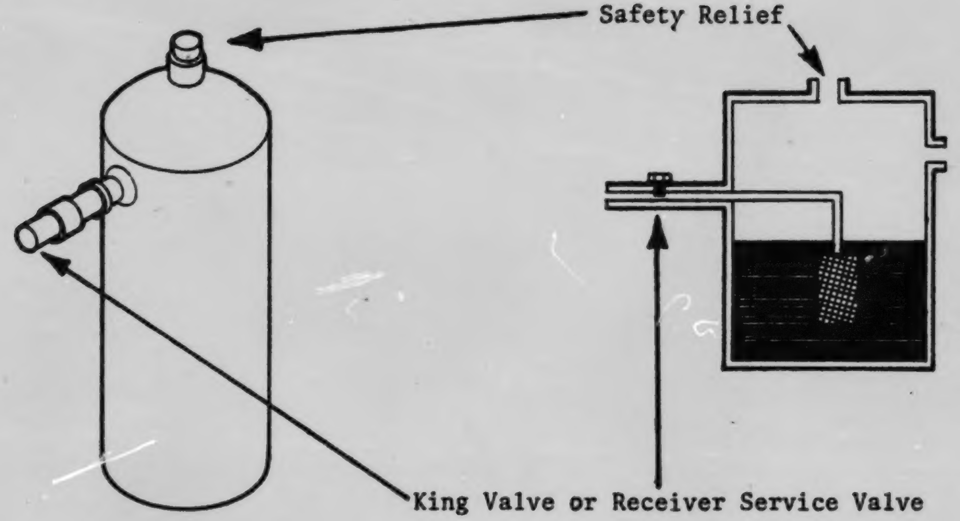
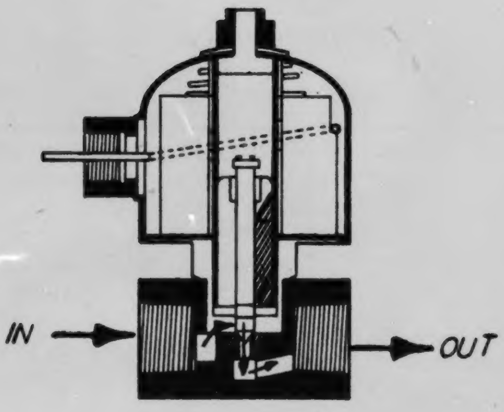


FIGURE A

Another way of pumping down the refrigeration system is with a valve open and closed by a magnetic coil (Figure B). The voltage to the Solonoid can be controlled by either a wall switch, temperature thermostat, defrost timer, or any device that will interrupt the electrical current going to the coil. In some cases, the coil is tied to the start coil of the compressor and will only allow the gas to flow when the compressor is running.

The electrical solenoid can be used to control various coils in the same room or in controlling temperatures in more than one room and at different degree settings. With a thermostat tied in series with the solenoid coil, it will cut the liquid off to any evaporator and stop it from refrigerating. (See Figure C)



Cross-section of solenoid refrigerant control valve used in liquid lines on air conditioning systems.

FIGURE B

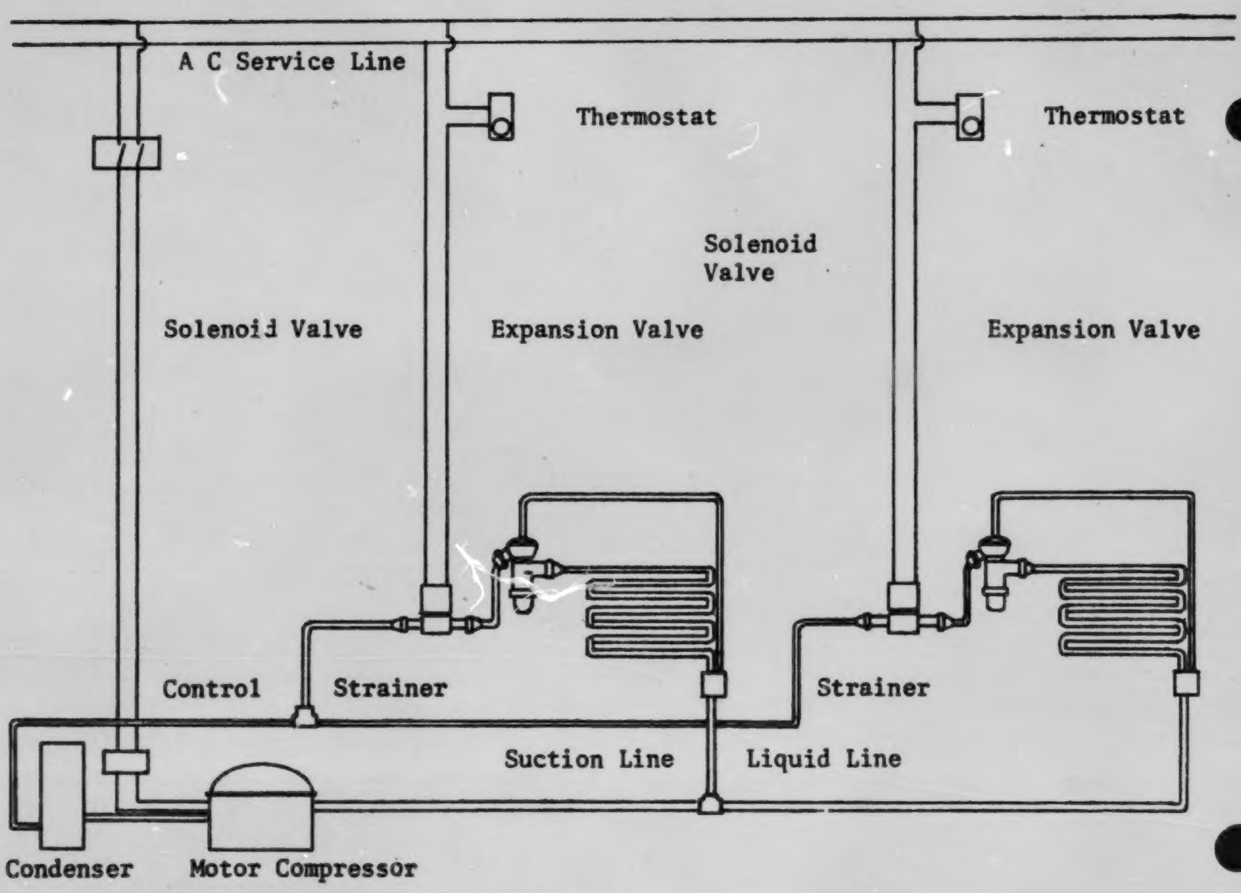
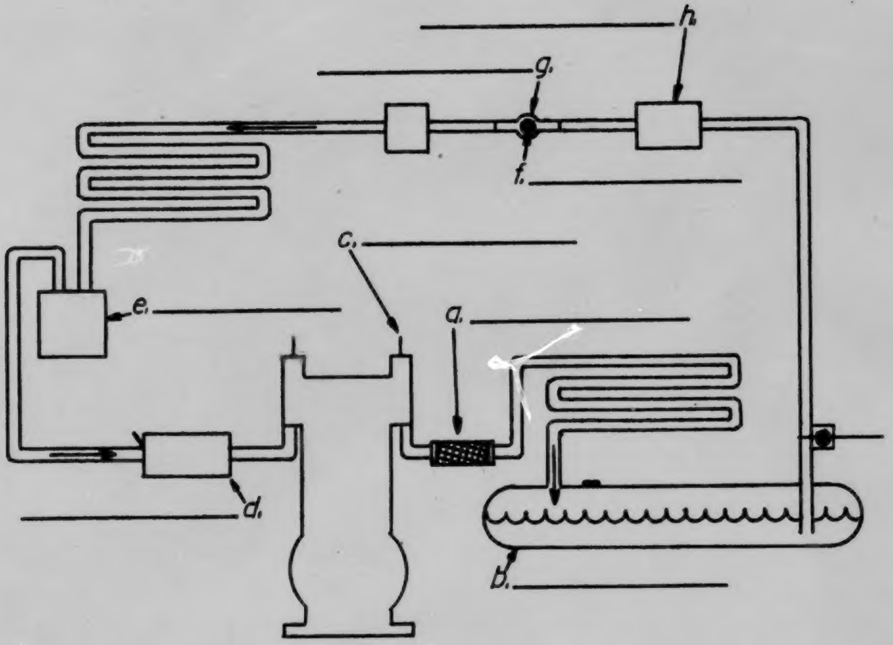


FIGURE C

Probably the most useful purpose for pump down is to be able to pump the gas into the high side of the system and then be able to take most of the component parts out of the low side of the system for servicing and replacement without losing the refrigerant. After work has been done on the low pressure side, the technician can pull a vacuum on the low side, open the valves and start back up.

Locate and identify the refrigerant system accessories.



Install a Liquid Indicator with Flare Fittings

1. Tools and materials
    a. Tubing cutter
    b. Flaring tool
    c. Flaring block
    d. Flare nut wrench
    e. Open end wrench
    f. Safety glasses
    g. Oil can
    h. Refrigeration gauge set
    i. Refrigeration system with an expansion valve
    j. Liquid indicator
    k. Flare nuts
2. Procedure
    a. Put on safety glasses
    b. Install refrigeration gauge set
    c. If refrigeration system is under pressure, slowly release pressure or pump down
    d. Cut liquid line between the outlet of the filter-drier and the inlet of the metering device
    e. Place flare nuts on tubing
    f. Flare the tubing
    g. Lightly oil fittings
    h. Install liquid indicator
    i. Tighten both flare nuts finger tight

Install a Filter-Drier with Sweat Fittings

1. Tools and materials
    a. Tubing cutter
    b. Torch
    c. Striker
    d. Colored safety glasses
    e. Safety glasses
    f. Refrigeration ratchet
    g. Refrigeration gauge set
    h. Refrigeration system
    i. Filter-drier with sweat firtings
    j. Silver alloy brazing rod
    k. Sand cloth
    l. Silver brazing flux
    m. Damp shop towel
    n. Nitrogen cylinder
2. Procedure
    a. Put on safety glasses
    b. Install refrigeration gauge set
    c. If refrigeration system is under pressure, slowly release pressure
    d. Use the sand cloth and polish the liquid line prior to cutting
    e. Cut liquid line close to the inlet of the metering device
    f. Check for proper direction of refrigerant flow
    g. Remove a section of liquid line the length of the filter-drier
    h. Repolish ends after cutting
    i. Apply flux to the polished ends

j. Remove the protective cap from one end of the filter-drier
(Note: On some small filter-driers used for domestic refrigeration, the ends must be cut off with a tubing cutter.)

k. Insert liquid line into one end of filter-drier

l. Twist the filter-drier while inserting the line to insure sufficient coating of flux

m. Remove protective cap from the other end of the filter-drier

n. Insert the other end of the liquid line

o. Twist the filter-drier while inserting the line
(Note: Special precautions are necessary when installing a capillary tube directly into a filter-drier. This procedure is covered in detail on a separate job sheet.)

p. If using a line-drier with an access core type valve, remove the core to prevent the heat from damaging it

q. Attach nitrogen cylinder to refrigeration gauge set

r. Adjust nitrogen regulator for 2 p.s.i.g.

s. Allow nitrogen to circulate through the system

t. Put on colored safety glasses

u. Light and adjust torch

v. Apply heat to joint; direct heat away from joint

w. Apply silver brazing alloy
(Caution: Cadmium free silver brazing alloy is the recommended alloy to use.)

x. Silver braze the other end

y. Turn off the torch

z. Clean the flux from both joints with a damp cloth before the joint cools

aa. Check both joints to be sure all of the flux is removed

bb. Have instructor inspect

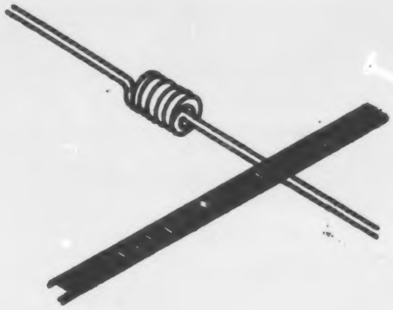
cc. Clean up and put tools away

Install a Capillary Tube into a Filter-Drier

1. Tools and materials
   - a. Tubing cutter
   - b. Flat file or taper file
   - c. Pliers
   - d. Torch
   - e. Striker
   - f. Colored safety glasses
   - g. Orifice drill set
   - h. Safety glasses
   - i. Refrigeration gauge set
   - j. Refrigeration system
   - k. Filter-drier (domestic refrigeration type)
   - l. Silver alloy brazing rod
   - m. Sand cloth
   - n. Silver brazing flux
   - o. Damp shop towel
2. Procedure
   - a. Put on safety glasses
   - b. Install refrigeration gauge set
   - c. If refrigeration system is under pressure, slowly release pressure
   - d. Cut liquid line close to the inlet of the metering device

e. Score the capillary tube with a file and break it off square (Figure D) (Note: Capillary tubing should not be cut with a tubing cutter as this will reduce the inside diameter of the capillary tubing.)

FIGURE D



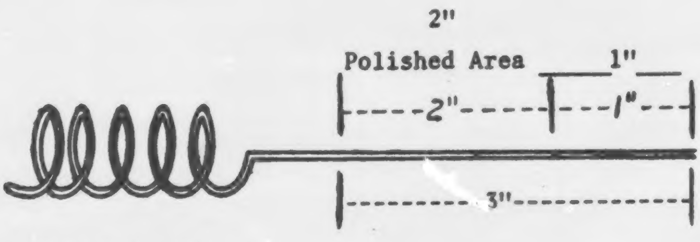
f. Straighten the end of the capillary tube; three inches should be sufficient.

g. Ream the end of the capillary tube with proper orifice file

h. One inch in from end of capillary tube, polish a two inch section (Figure D)

(Note: If one inch of the capillary tube is left uncleaned, the silver alloy will have less tendency to flow down the tube and restrict the end.)

FIGURE E



i. If using a filter-drier with an access core type valve, remove the core to prevent the heat from damaging it.

MAJOR BLOCK Refrigeration **NAME** ____________

TASK Refrigerants

UNIT Testing For Leaks **TIME (est.)** ________ **(act.)** ______

UNIT NO REF-17

OBJECTIVE(S) Demonstrate the ability to leak test by, soap bubbles, halide torch, and electronic detector.

START ➔ W-1 ➔ W-2 ➔ L-1 ➔ A-1 ➔ C-1 ➔ L-2 ➔ C-2 ➔ L-3 ➔ C-3 ➔ L-4 ➔ C-4

WRITTEN ASSIGNMENT(S)		**AUDIOVISUAL(S)**	
W-1	Text Assignment REF-17a	**A-1**	Slide Set REF-17a
W-2	Information Sheet REF-17a	**A-2**	
W-3	Text Assignment REF-17b	**A-3**	
W-4		**A-4**	
W-5		**A-5**	
W-6		**A-6**	
W-7		**A-7**	

LABORATORY ASSIGNMENT(S)		**CHECKPOINT(S)**	
L-1	Job Sheet REF-17a	**C-1**	Instructor Check
L-2	Job Sheet REF-17b	**C-2**	Instructor Check
L-3	Job Sheet REF-17c	**C-3**	Instructor Check
L-4	Job Sheet REF-17d	**C-4**	Instructor Check
L-5		**C-5**	
L-6		**C-6**	
L-7		**C-7**	
L-8		**C-8**	
L-9		**C-9**	

PRESSURIZING AND LEAK TESTING

1. Terms and definitions

   A. Dry nitrogen--Oil pumped nitrogen in a pressurized cylinder, used for pressurizing refrigeration components and sweeping the system while soldering or brazing.

   B. Regulator--Device used for reducing high cylinder pressure to a low working pressure. This should never be run above the test pressure on the low side.

   C. Acid brush--Small, stiff bristle brush which is often used for applying flux or soap bubbles.

II. Safety rules for pressurizing a refrigeration system

   A. Wear safety glasses.

   B. Never use oxygen or acetylene to pressurize a system. Oxygen will explode on contact with oil. Acetylene will explode under pressure above 15 p.s.i.g.

   C. Never use dry nitrogen without a regulator. Nitrogen cylinders contain pressures in excess of 2000 p.s.i.

   D. Never apply intense heat to a pressurized cylinder or system.

   E. Refrigeration systems must never be pressurized above test pressure for leak test.

PRESSURIZING AND LEAK TESTING

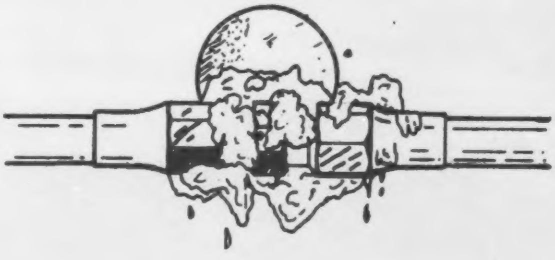
Leak Check Using Soap Bubbles

1. Check with the instructor for assignment to a refrigeration system to leak test using the "soap bubble" method.

2. Tools and materials
   A. Refrigeration gauge set
   B. Soap bubble solution
   C. Acid brush (clean)
   D. Refrigeration ratchet
   E. Open end wrench
   F. Refrigeration system assigned by instructor
   G. Clean shop towel

3. Procedure
   A. Connect refrigeration gauge set to the refrigeration system
   B. Crack service valves
   C. Allow the pressures to equalize. If there is not positive pressure on the entire system, do not apply the soap solution until the system is pressurized with the type gas used in system.
   D. Locate areas of suspected leaks
   E. Apply the soap solution
   F. Look for a bubble that would indicate a leak
   G. Remove soap solution after checking
   H. Write location of leak

FIGURE A



PRESSURIZING AND LEAK TESTING

Leak Check Using A Halide Torch

1. Check with the instructor for assignment to a refrigeration system to leak test using a Halide Torch.

2. Tools and materials
   - A. Refrigeration gauge set
   - B. Halide torch
   - C. Striker
   - D. Safety glasses
   - E. Refrigeration ratchet
   - F. Open end wrench
   - G. Refrigeration system

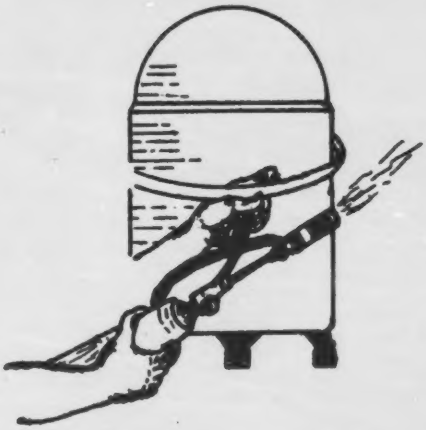


FIGURE B

3. Procedure
   - A. Connect refrigeration gauge set to the refrigeration system
   - B. Crack service valves
   - C. Allow the pressures to equalize
   - D. Locate areas of suspected leaks
   - E. Light the halide torch
   - F. Hold the sniffer hose of the torch so that the hand will trap the refrigerant

Job Sheet REF-17c

Leak Check Using An Electronic Detector

1. Check with the instructor for assignment to a refrigeration system to leak test using an electronic leak detector.

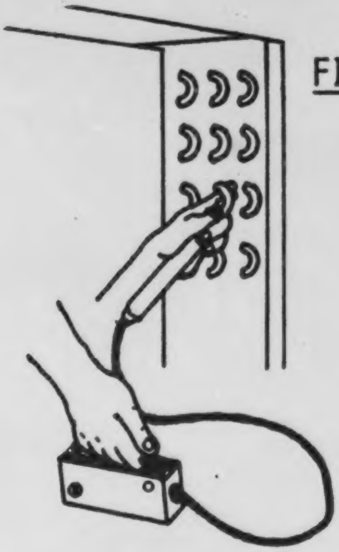


FIGURE C

2. Tools and materials
   - A. Refrigeration gauge set
   - B. Electronic leak detector
   - C. Refrigeration ratchet
   - D. Open end wrench
   - E. Refrigeration system

3. Procedure
   - A. Connect refrigeration gauge set to the refrigeration system
   - B. Crack service valves
   - C. Allow the pressures to equalize
   - D. Locate areas of suspected leaks
   - E. Turn on electronic leak detector
   - F. Allow 3 to 5 minutes for detector to warm up. Some units can be damaged by too much freon.
   - G. Adjust the leak detector. If problems adjusting detector arise, re-read instructions.
   - H. Hold the probe underneath the suspected leak area

I. Watch and/or listen for the detector to indicate a refrigerant leak.

J. Recheck the leak with the soap solution

K. Remove the soap solution after checking

L. Give location of leaks

LEAK CHECK USING REFRIGERANT PLUS NITROGEN

1. Check with the instructor for assignment to a refrigeration system to leak test using the refrigerant plus nitrogen method.

2. Tools and materials

   A. Refrigeration gauge set

   B. Halide torch and/or electronic leak detector

   C. Refrigeration ratchet

   D. Open end wrench

   E. Safety glasses

   F. Dry nitrogen

   G. Refrigeration system

   H. Refrigerant 12 or 22

3. Procedure

   A. Connect refrigeration gauge set to the refrigerant system

   B. Crack service valves

   C. Attach refrigerant cylinder to the center hose of the gauge set

   D. Leave refrigerant cylinder in the upright position

   E. Open refrigerant cylinder valve

   F. Open the valve on the high side of the gauge manifold

   G. Allow refrigerant pressure to equalize at 50 p.s.i.g.

   H. Close high side manifold valve

   I. Close refrigerant cylinder valve

   J. Loosen refrigerant hose at cylinder valve

   K. Allow hose pressure to escape

L. Remove hose from refrigerant cylinder

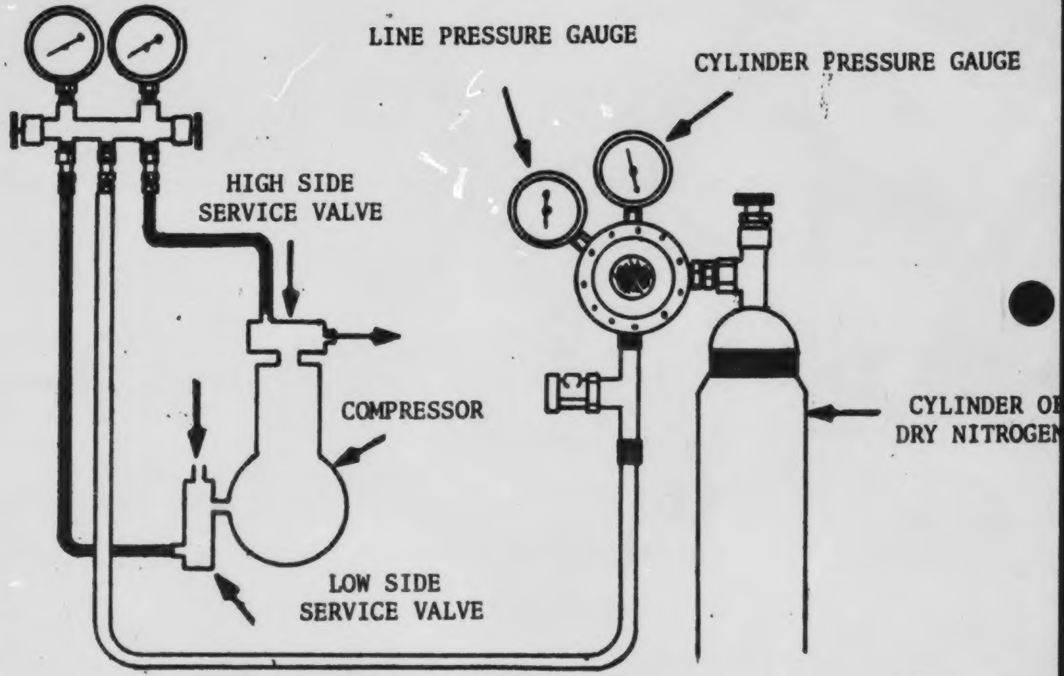
M. Attach gauge set center hose to nitrogen regulator

N. Check to be sure regulator adjusting screw is not turned in

O. Crack the nitrogen cylinder valve one-quarter of a turn

P. Purge center hose

FIGURE D



Q. Turn regulator and adjusting screw clockwise until desired pressure is obtained. 100 p.s.i. should be sufficient

R. Open valve on the high side of the gauge manifold

S. Allow high side and low side pressure to equalize

T. Leak check the system with a halide torch and/or an electronic leak detector

U. List leaks found

MAJOR BLOCK Refrigeration **NAME** ____________

TASK Refrigerants

UNIT Charging the System **TIME (est.)** ________ **(act.)** ________

UNIT NO REF-18

OBJECTIVE(S)

Demonstrate the ability to charge a unit by vapor and by liquid, using charts and manifold gauges, showing knowledge of the use of the sight glass, frost back and weighing refrigerant into unit.

START ➡ W-1 ➡ W-2 ➡ W-3 ➡ A-1 ➡ W-4 ➡ C-1 ➡ A-2

W-5 ➡ L-1 ➡ C-2 ➡ L-2 ➡ C-3

WRITTEN ASSIGNMENT(S)		**AUDIOVISUAL(S)**	
W-1	Information Sheet REF-18a	**A-1**	Slide Set REF-18a
W-2	Information Sheet REF-18b	**A-2**	Slide Set REF-18b
W-3	Information Sheet REF-18c	**A-3**	
W-4	Assignment Sheet REF-18a	**A-4**	
W-5	Text Assignment REF-18a	**A-5**	
W-6		**A-6**	
W-7		**A-7**	

LABORATORY ASSIGNMENT(S)		**CHECKPOINT(S)**	
L-1	Job Sheet REF-18a	**C-1**	Instructor Check
L-2	Job Sheet REF-18b	**C-2**	Instructor Check
L-3		**C-3**	Instructor Check
L-4		**C-4**	
L-5		**C-5**	
L-6		**C-6**	
L-7		**C-7**	
L-8		**C-8**	
L-9		**C-9**	

Charging

I. Terms and definitions or descriptions.

  A. Upright - Refrigerant cylinder is standing up with valve on top and vapor is dispensed from the cylinder.
  B. Inverted - Refrigerant cylinder is turned upside down with valve on bottom and liquid is dispensed from the cylinder.
  C. Hose purging - Releasing some refrigerant to the air to remove contaminants from the gauge hoses.
  D. Stabilized - Condition that shows a constant gauge reading.
  E. Static pressure - Pressure readings of a system when it is not running.

II. Safety precautions for refrigerant handling.

  A. Do not drop cylinders.
  B. Do not refill disposable refrigerant cylinders.
  C. Do not heat cylinders with a torch.
  D. Secure cylinders in a moving vehicle.
  E. Do not spray refrigerant on skin.
  F. Do not inhale refrigerant.
  G. Do not spray refrigerant into open flame.
  H. Do not mix refrigerants.
  I. Replace cylinder cap when not in use to protect valve.
  J. Do not lift or carry cylinder by valve.
  K. Secure large cylinders to wall or bench.
  L. Have adequate ventilation.
  M. Remove valve or puncture cylinder when discarding disposable refrigerant cylinders.

Charging a Refrigeration System

The main job of the installer or service engineer is to keep highly precise modern mechanical cooling systems running according to design specifications. Always follow factory specifications for best performance of the equipment.

Not all systems use the same refrigerant and not all systems use the same amount of charge, even though capacity may be entirely comparable.

Check the Name Plate

All units should have a plate listing the refrigerant. Some show the exact amount of refrigerant needed, the test pressure of the condenser (High Side), and the test pressure for the low side. Note, this is not operating pressure, only test pressure. Do not pressurize above this pressure in checking for leaks. Too much pressure will create a leak.

Charging by Sight Glass

This method works fine on a system in which everything is working correctly. The sight glass in a refrigeration system permits the installer or serviceman to observe the condition of the refrigerant at that particular point.

The sight glass usually consists of a glass opening in the liquid line of the system. Frequently a glass on each side of the line is used to assure illumination or light within the line.

When the line is completely filled with liquid refrigerant, there is almost no obstruction when looking through the line. However, if any gas is contained within the liquid line, it will show immediately in the form of bubbles passing through the sight glass. It should be pointed out that in a sight glass of this type, the glass will also show clear when gas only is present.

Bubbles in a sight glass can appear in a system that has the correct amount of gas in it. This can be caused by several reasons; for example, restriction before the sight glass, or frozen up evaporator (meaning excessive liquid is staying in the evaporator). An understanding of the basic cycle of refrigeration and why it works can help to understand why these bubbles could appear, making the peep sight glass unreliable.

The same thing can be true of the sight glass when there is not enough refrigerant in the system. The sight glass can show full because of restriction in front of the sight glass. In this case, the liquid is not going through, and the sight glass stays full when gas is low in the system.

Frost Back Method

This method can only be used in small hermetic systems which use capillary tubes, such as room air conditioners. When a system of this type is operated without evaporator load, the back pressures will normally drop below the freezing temperature and frost will form on the coil.

The evaporator load can be removed by placing a piece of cardboard over the coil face, thus shutting off the air flow. As the load is removed from the evaporator, the refrigerant will not evaporate as rapidly and some will pass through the evaporator and evaporate in the suction line. Tests have shown that under these conditions, a properly charged unit will normally frost to within a few inches of the compressor.

This method is used on most refrigerators and freezers where the amount of refrigerant is not known, or has been changed by adding or leaving out something such as a liquid dryer. This will alter the amount needed because of the amount of gas it holds. Remember, the peep sight glass can't be used on a capillary system.

Charging Methods

There are two methods of charging refrigeration systems: vapor charging and liquid charging. The general procedure to follow in both of these methods is outlined, assuming the system has been tested for leaks, dried and evacuated.

Refrigerant, confined under its own pressure, contains considerable stored energy. This stored energy can be dangerous and destructive if it is accidentally released in some uncontrolled manner. When refrigerant is heated, its pressure must increase. This is an outward indication of increasing energy content. A second effect of heating is an increase in the volume occupied by a given weight of liquid. If one could look inside a cylinder, the liquid level would be seen to rise as the temperature increases.

Where heating must be done, precautions should be taken:

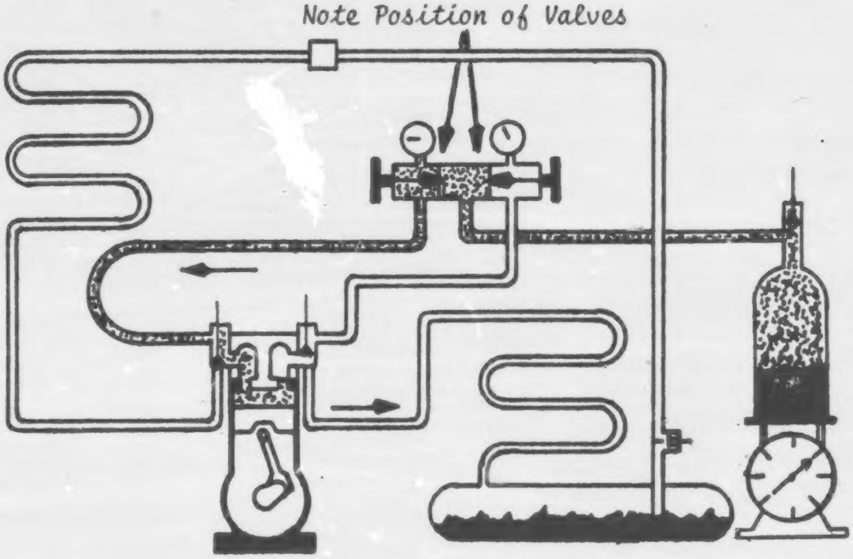
1. Wait until part of the refrigerant has been withdrawn from a full cylinder before doing any heating. This will reduce the likelihood of a liquid-fill situation
2. Limit the maximum temperature exposure of the cylinder to some limit below the 130° F. level.
3. Never obstruct or tamper with the safety relief device. Never introduce refrigerant into a cylinder which has none.

Check the nameplate on factory-assembled systems. All manufacturers include a nameplate that clearly lists the refrigerant for which the system was designed. Always check the nameplate before charging or adding refrigerant to a system. This makes it doubly important always to check the nameplate where amount of charge is stamped.

In all the charging methods used it is important to watch the temperature of the compressor, realizing that the cold gas coming to a hermetic compressor is the only real way of cooling it. Compressor temperature can be held down by stopping the unit and waiting, cooling the compressor with wet rags and by fans blowing on the compressor.

P

FIGURE A

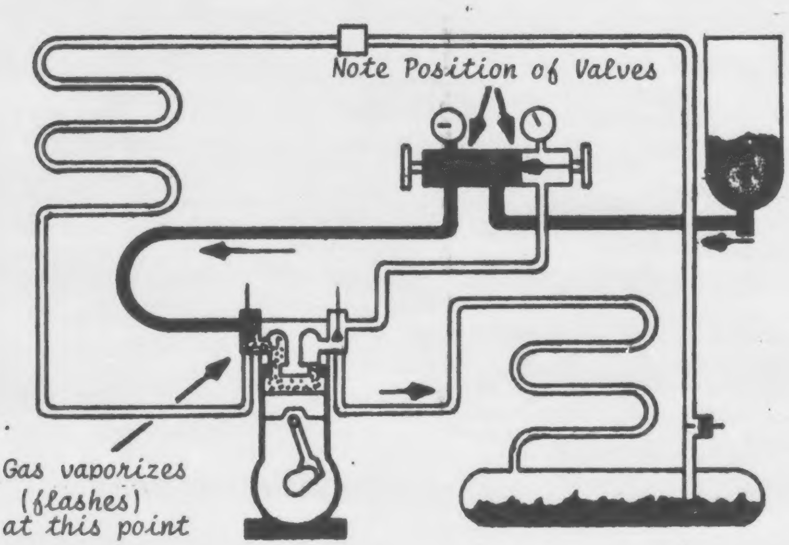


Low Side Vapor Charging

Low side vapor charging is the safest method for the equipment. It is important to understand the basic cycle before attempting to charge a system. Figure A will help to review the cycle and also see why vapor charging should be used until the service technician fully understands when liquid can be charged into the low side. Some manufacturers recommend that low side liquid charging never be done on their units because of the equipment design. Charging vapor into the low side will prevent a lot of problems.

By allowing the vapor to enter the suction service valve, it will be picked up by the compressor and sent to the condenser, then to the evaporator where it should boil out to a vapor again before it gets back to the compressor (Refer to Figure A for correct hook-up of charging equipment).

FIGURE B

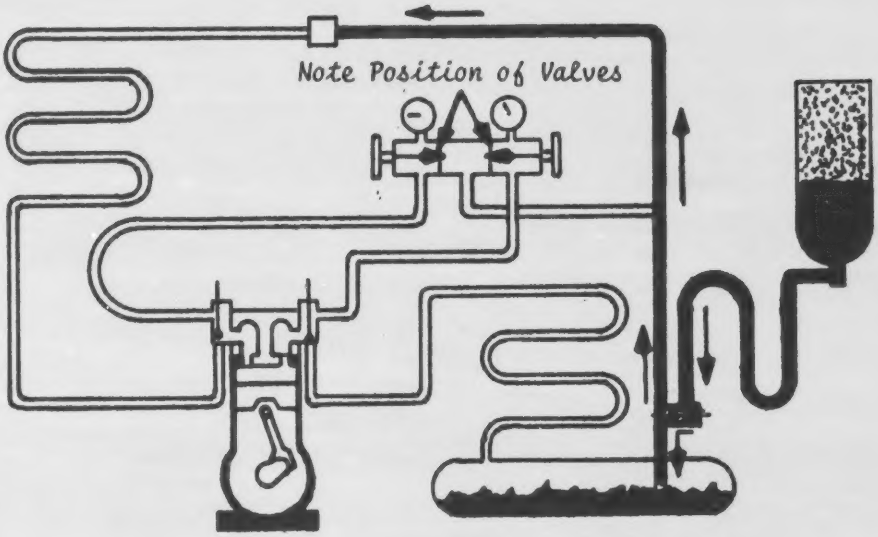


Low Side Liquid Charging

Low side liquid charging can be used only be a service technician highly skilled in charging procedures. It is used on many systems large enough that the liquid coming through the service hose and valve would not be more than the compressor could handle without allowing some of it to get to the pistons.

Schrader valves can be used to help restrict the flow of liquid . Items are also available from several companies which help in causing the liquid to flash before it enters the compressor. Liquid charging should be supervised by the instructor until the student fully understnad the dangers of damage that liquid can cause in the compressor. (Refer to Figure B for correct hook-up of charging equipment).

FIGURE C



High Side Liquid Charging at the King Valve

This is one of the easiest ways and fastest ways of getting into a system. If the king valve is closed off, the flow of liquid is stopped any any liquid will stay in the high side. If the liquid is put into the system in front of the king valve, it will travel to the metering device and boil out in the evaporator. It is important to know how much liquid to put into the system. (Refer to Figure C for correct hook up of charging equipment).

Self Check Charging Test

1. Match the terms on the right to the correct definitions or descriptions.

_____a. Refrigerant cylinder is turned upside down with valve on bottom and liquid is dispensed from the cylinder.
_____b. Condition that shows a constant gauge reading.
_____c. Releasing some refrigerant to the air to remove contaminants from the gauge hoses.
_____d. Pressure readings of a system when it is not running.
_____e. Refrigerant cylinder is standing up with valve on top and vapor is dispensed from the cylinder.

1. Hose purging
2. Static pressure
3. Upright
4. Stabilized

2. List two advantages and two disadvantages of low side vapor charging.

a. Advantages:

1.

2.

b. Disadvantages:

1.

2.

3. Select the advantages and disadvantages of high side liquid charging by placing an "X" by the advantages and an "0" by the disadvantages.

_____a. Fast
_____b. Slow
_____c. System must be running
_____d. Easy to overcharge
_____e. Impossible to overcharge
_____f. System may have to be turned off

Vapor Charging

Tools needed:

Manifold Gauge
Refrigeration Wrench
Crescent Wrench

Equipment Needed:

Refrigerant and unit assigned by instructor

Vapor Charging:

Small systems are usually vapor charged through the gauge port of the compressor suction service valve. To carry out a vapor charging procedure, the following steps should be taken:

1. Back-seat suction service valve for normal operation.
2. Loosely connect line from service manifold to suction service valve gauge port.
3. Connect center line from manifold to the refrigerant cylinder. It is recommended that new refrigerant from a factory-filled cylinder is used. (If a factory-filled cylinder is not used, always install a fully activated filter-drier in the charging line.)
4. Back-seat discharge service valve.
5. Loosely connect remaining line from service manifold to discharge service valve gauge port.
6. Purge vapor from cylinder up to compressor discharge valve (cylinder upright).
7. Tighten high-side service valve connection at gauge port.
8. Purge vapor from cylinder up to compressor suction valve.
9. Tighten low-side service valve connection at gauge port.
10. Place cylinder of refrigerant on platform scale.
11. Pressurize system to full cylinder pressure and make final leak check.
12. Start compressor and wait until head pressure and suction pressure stabilize. If the system is equipped with a low-pressure control that starts to short cycle the compressor, note the cutout pressure and admit refrigerant from cylinder to increase suction pressure by 10 to 15 pounds gauge over the cutout setting.

    Open the cylinder valve wide and control the flow of refrigerant from the manifold. Occasionaly during the procedure, note the suction pressure with cylinder valve closed; and, note the discharge pressure to see that it does not rise above what would normally be expected under usual operating conditions. For air-cooled systems, pressure corresponding to ambient temperature plus 20 degrees F (refrigeration should approximate the discharge pressure).

13. When proper weight of refrigerant has been introduced, close cylinder valve and manifold valve and disconnect charging line. If it is at all possible, refrigerant should always be charged by weight, using a good scale, or by volume using a charging cylinder with a scale which compensates for changes in the density of refrigerants due to temperature and with different scales for different refrigerants. If a sight glass is installed in the liquid line, refrigerant can be charged until no bubbles are visible, indicating that the liquid line is full of liquid.
14. When satisfied the system is operating as it should, back-seat the suction and discharge service valves and bleed pressure from both gauge lines through the manifold charging port.
15. Replace the cap or cylinder valve cover and install flare plugs in open ends of the charging and gauge lines. Replace the plugs in the gauge ports of service valves.

Liquid Charge

Tools Needed:

Manifold gauge set
Refrigeration wrench
Crescent Wrench

Equipment and Supplies:

Refrigerant and unit assigned by instructor

1. Connect the refrigerant cylinder to the charging port. Use as short a line as possible to minimize water contamination, or use a drier if indicated by conditions. The cylinder should be upside down unless it has a liquid/vapor valve.
2. Install a pressure gauge so the discharge pressure can be observed.
3. With the connection to the charging port loose, crack cylinder valve and purge charging line with refrigerant. Tighten the connection, open cylinder valve and check for leaks.
4. Close the valve at the receiver outlet, or if there is no receiver, close the valve in the liquid line upstream from the charging port. This is necessary to prevent the condensing pressure from forcing liquid into the cylinder.
5. With the compressor running, slowly open the charging port valve and charge liquid at a rate, if possible, fast enough to keep the compressor from cutting out on the low-pressure control. The refrigerant flow can also be controlled by the cylinder valve and avoid ending up with a hose full of liquid refrigerant.
6. Watch the discharge pressure. A rapid rise in pressure indicates the condenser is filling with liquid. If this is the case, the system pump-down capacity has been exceeded. Stop charging from the cylinder and open the liquid line valve. If the system still seems low on charge, an auxiliary receiver may be needed.
7. When the proper weight of refrigerant has been added, close the cylinder valve and let the low-pressure control stop the compressor.
8. Close the charging port valve and vent the refrigerant from the hose by loosening the connection.
9. Open the liquid line valve or receiver outlet valve and check the operation of the system.
10. Replace the cap on the cylinder valve and charging valve. Plug both ends of the charging hose or manifold so it will be clean for the next use.

The following suggestions may be useful if a sight glass is not installed and information on the correct charge is not available.

1. Connect charging line and gauge manifold to the compressor.
2. Attach thermometer to the evaporator outlet.
3. Run the compressor and after about ten minutes, read both gauges and the thermometer.

4. Add refrigerant, vapor phase.
5. Close cylinder valve and after a few minutes, read the suction and discharge pressure and the thermometer. Both gauges should read a little higher. The thermometer may read a bit lower. On water-cooled systems having a good supply of cold water, the discharge pressure may not increase.
6. Repeat Steps 4 and 5 until no further change is noted in the gauge reading.
7. Read the thermometer and check against the refrigerant saturation temperature as shown by the suction pressure gauge...that is, the corresponding refrigerant temperature at low-side pressure. The difference between saturation temperatures at evaporator pressure and the thermometer reading should be the superheat setting of the expansion valve. This value is usually 10° F. Allow for a thermometer reading of 2° F higher than the actual vapor temperature.
8. Again, add a small amount of refrigerant and observe the thermometer for any change. No change indicates that full liquid flow is being supplied to the expansion valve. System operating conditions must have been reached and equilibrium established before this final reading is made.
9. Add a reserve of refrigerant based on size of the system.

The above procedure can be applied to capillary tube systems with the exception of Step 9.

MAJOR BLOCK Refrigeration **NAME** ____________

TASK Troubleshooting

UNIT Testing the Compressor **TIME (est.)** ______ **(act.)** ______

UNIT NO REF-19

OBJECTIVE(S)

After you complete this, you will be able to safely troubleshoot and replace a refrigeration compressor.

START	➔	W-1	W-2	W-3	C-1	A-1	L-1	C-2
L-2	C-3							

WRITTEN ASSIGNMENT(S)		**AUDIOVISUAL(S)**	
W-1	Information Sheet REF-19a	**A-1**	Slide Set REF-19a
W-2	Text Assignment REF-19a	**A-2**	
W-3	Assignment Sheet REF-19a	**A-3**	
W-4		**A-4**	
W-5		**A-5**	
W-6		**A-6**	
W-7		**A-7**	

LABORATORY ASSIGNMENT(S)		**CHECKPOINT(S)**	
L-1	Job Sheet REF-19a	**C-1**	Instructor Check
L-2	Job Sheet REF-19b	**C-2**	Instructor Check
L-3		**C-3**	Instructor Check
L-4		**C-4**	
L-5		**C-5**	
L-6		**C-6**	
L-7		**C-7**	
L-8		**C-8**	
L-9		**C-9**	

Testing the Compressor

As stated previously, the compressor has two main functions in the refrigeration system. Basically, these two functions are to remove the vaporized refrigerant from the evaporator and to increase pressure/temperature so the vapor can be condensed.

In the refrigeration industry four principle types of refrigeration compressors are manufactured. They are:

1. The reciprocal compressor which is the most widely used in the industry, and is manufactured in many designs. This type of compressor can be compared to an automotive engine, with its pistons, crankshaft and valves. This is illustrated in Figure A.

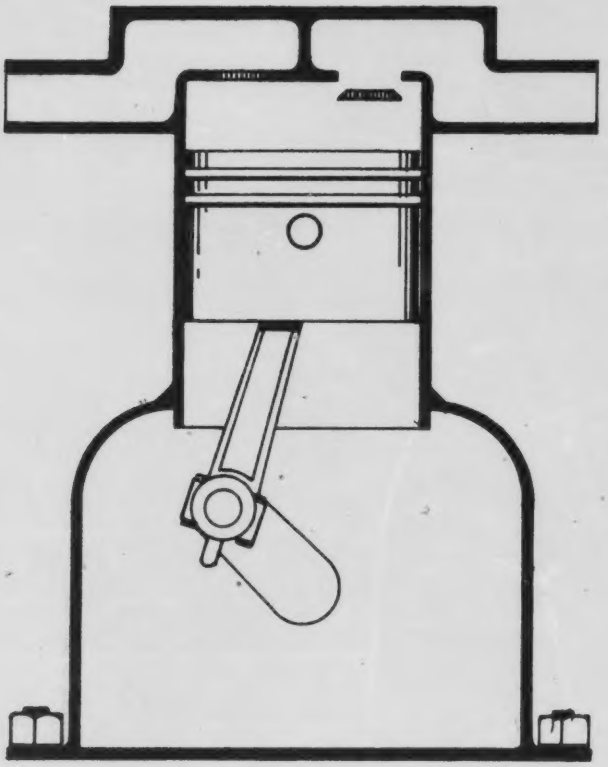


FIGURE A

2. The rotary compressor is also widely used in household refrigeration. This type of compressor operates with a circular motion. Compression is accomplished by having a rotating cylinder operation "off center" in a housing. As vapor is brought into the housing it is trapped behind pistons or blades and forced around to the point where the chamber is smallest. At this point it is discharged into the refrigeration system. This process is shown in Figure B.

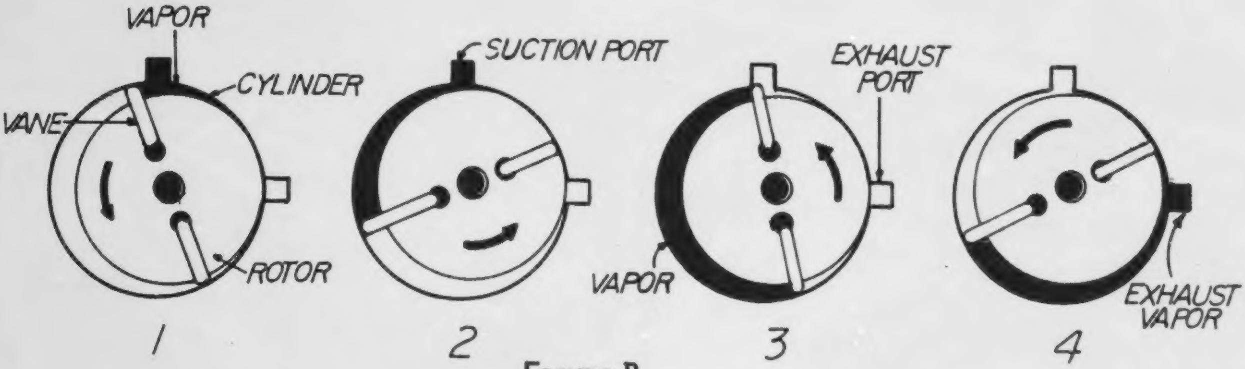


FIGURE B

3. The centrifugal compressor is used in large refrigeration systems here. Basically, this compressor operates by taking the vaporized refrigerant into an impeller chamber at the center of the impeller. The impeller turns at a high rate of speed which throws the vapor to the outer end of the impeller and into a compressor chamber, then into the refrigeration system. This impeller can be operated by an electric motor or steam turbine. The impeller and chamber are shown in Figure C.

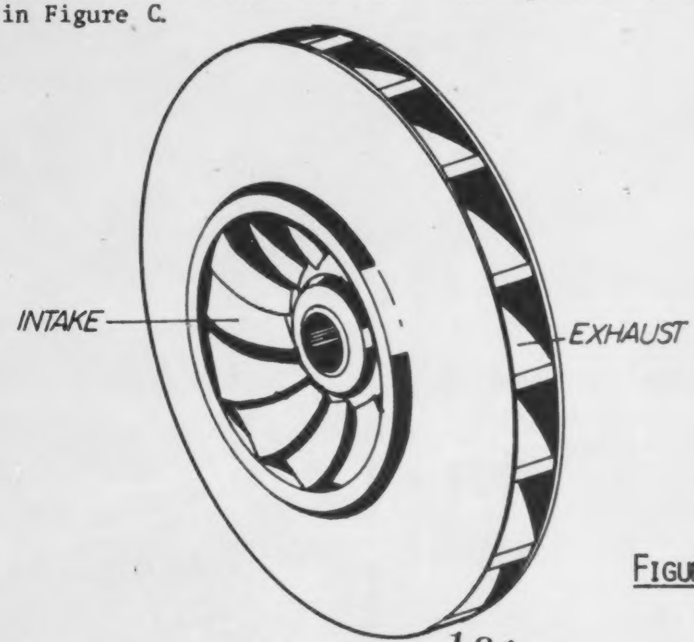


FIGURE C

4. **The screw type compressor is mainly used in large refrigeration systems. Since this compressor is not used in household refrigeration it too will only be discussed briefly. This compressor has two rotating impellers, one of which has large grooves similar to the threads on a screw. In operation, the other impeller will mate with these grooves when vapor is trapped in the grooves and forced the length of the impeller into a smaller chamber, compression is accomplished. This is shown in Figure D.**

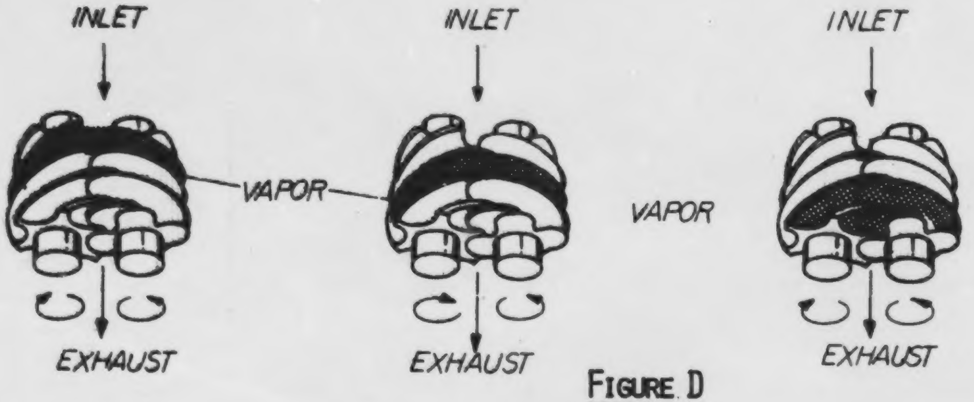


FIGURE D

As stated above, the recriprocating compressor is the most popular and most widely used in the industry and is the only type used in household applications. It may be further classified as hermetic, semi-hermetic, or open. The hermetic type is a compressor and motor assembled together and sealed in a housing at the factory. The motor is pressed on to the crankshaft and can be at the top or bottom of the housing. This type of compressor, however, cannot be repaired in the shop or on the job and must be returned to the factory for repair. One basic design of this type compressor is shown in Figure E.

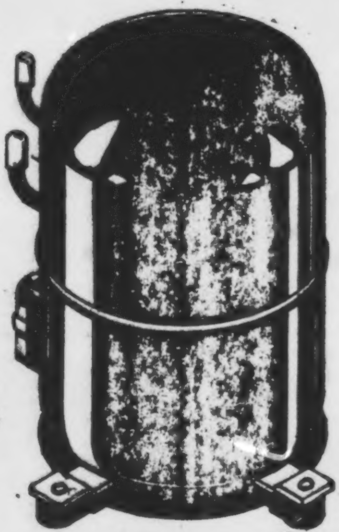


FIGURE E

The semi hermetic compressor is used in small commercial refrigeration systems and can be found extensively cooling food counters at supermarkets. This type of compressor also has the motor and compressor mounted on the same shaft and sealed in a common housing. The main difference in the two is that this type of compressor can be disassembled and repaired. (See Figure F).

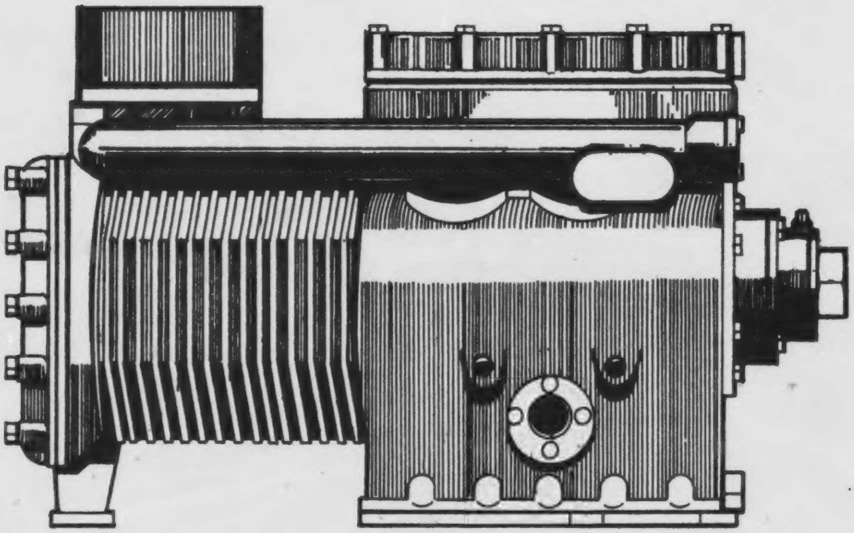


FIGURE F

An open compressor is never used in household refrigeration. It is mainly used in larger commercial applications. Its operation is the same as a reciprocating compressor. However, it is driven by a power source outside of the compressor housing. This is usually accomplished by belts. The power source can be either electric motor, steam turbine or gas/diesel engine. The design of this compressor is shown in Figure G.

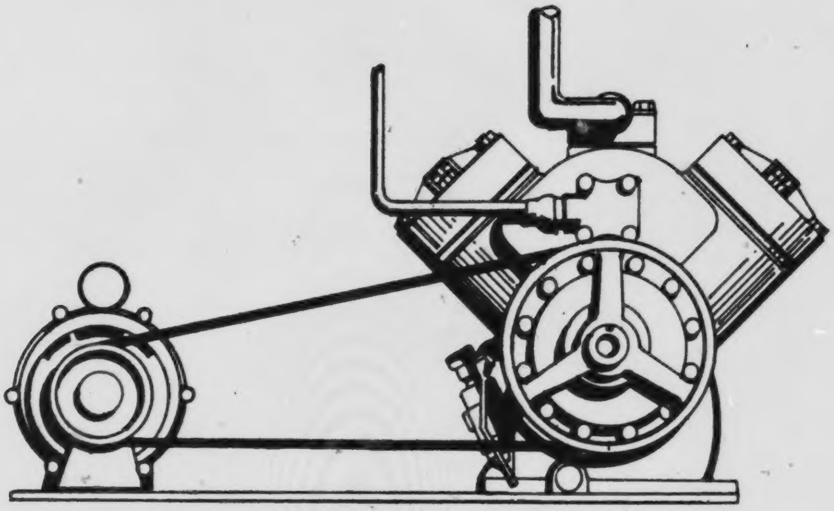


FIGURE G

Next, an outline of some troubleshooting techniques and procedures for the hermetic reciprocating and hermetic rotary compressors will be given. As pointed out before, repair of these compressors are limited to the factory. However, identifying problems is the responsibility of the refrigeration mechanic and an error in judgement can cost much time and money. For example, consider the lost time when a compressor is replaced in a system only to find the refrigerator still will not cool. Or, replacing a compressor when the external overload was the only problem. These two examples may not be common, but they have happened.

In a hermetic compressor there are very few checks which can be made. However, they are sufficient to determine if the compressor needs to be replaced. When a refrigerator is not cooling and the compressor is thought to be at fault, the following steps should be taken:

1. By connecting a good set of manifold gauges to the service valve in the system it can be determined if the system has enough refrigerant to operate. Unplug the refrigerator and allow to remain idle long enough to allow the system pressure to equal the pressure indicated on a pressure/temperature chart for the type refrigerant and ambient temperature. If the pressure indicated is within the area on the chart, start the compresser and see if the pressure changes. If the pressure does not change, a mechanical problem exists within the compresser. This problem is most frequently associated with valves. However, as stated earlier, on hermetic compressors repairs must be made at the factory. Therefore the compresser has to be replaced. At this time it would be advisable to place two service valves in the system. One on the high pressure side of the compressor and one on the low pressure side. After this is completed and the unit is started, the guage on the low pressure side should drop and the high side pressure guage should indicate a rise. If this occurs and the pressures are within manufacturers specifications, then the compresser is good.

Assignment Sheet REF-19a

Testing the Compressor

Using the text assignment and previous informaton match the symptoms listed in the left column to the problems listed in the right column

SYMPTOM	PROBLEM
1. Noisy compressor	A. Compressor stuck due to lack of oil
2. Low or no pressure while compressor is operating	B. Internal failure
3. Compressor hums but will not start	C. Shock mounts on compressor deteriorated
4. Compressor overheating	D. Valves inoperative
	E. Lack of refrigerant
	F. Slugging

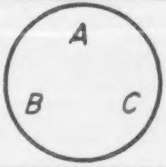
Job Sheet REF-19a

Test compressors using volt, ohmmeter

1. Check out VOM
2. Using compressors assigned by instructor find common, start, and run.

   Test for shorts, open, winding and ground.

   NOTE: You may not find C.R.S. if the compressor is shorted, open or grounded.

Compressor #	Draw diagram of Term. and indicate CRS	Short	Open	Ground
Example	A C B S C R 			✓
#1	A _____ B _____ C _____			
#2	A _____ B _____ C _____			
#3	A _____ B _____ C _____			
#4	A _____ B _____ C _____			
#5	A _____ B _____ C _____			

Compressor #	Draw diagram of Term. and indicate CRS	Short	Open	Ground
#6	A _____ B _____ C _____			
#7	A _____ B _____ C _____			
#8	A _____ B _____ C _____			
#9	A _____ B _____ C _____			
#10	A _____ B _____ C _____			

Direct Test Compressor

1. Check out compressor direct tester and safety glasses.
2. Using compressors tested in previous job sheet direct test only those compressors that checked O.K.
3. Connect test cord as indicated on tester. Connect common, start and run leads to compressor terminal. Connect capacitor leads together.
4. Turn tester on and push start button momentarily. If compressor runs do not operate for more than 10 seconds as damage could result to compressor. Turn tester off.
5. If compressor does not run, connect capacitor leads to a good capacitor size 88 - 108 MFD and 125 volt.
6. Repeat Step 4.
7. If compressor does not run it is stuck mechanically.

List Compressor # Checked	Compressor Runs	Compressor Stuck

MAJOR BLOCK Refrigeration **NAME** ____

TASK Troubleshooting

UNIT Applying Principles of Condensers **TIME (est.)** ____ **(act.)** ____

UNIT NO REF-20

OBJECTIVE(S)

Identify, remove, and replace a faulty condensor.

START → W-1 → W-2 → C-1 → W-3 → L-1 → C-2

WRITTEN ASSIGNMENT(S)

W-1 Text Assignment REF-20a
W-2 Assignment Sheet REF-20a
W-3 Text Assignment REF-20b
W-4 ____
W-5 ____
W-6 ____
W-7 ____

AUDIOVISUAL(S)

A-1 ____
A-2 ____
A-3 ____
A-4 ____
A-5 ____
A-6 ____
A-7 ____

LABORATORY ASSIGNMENT(S)

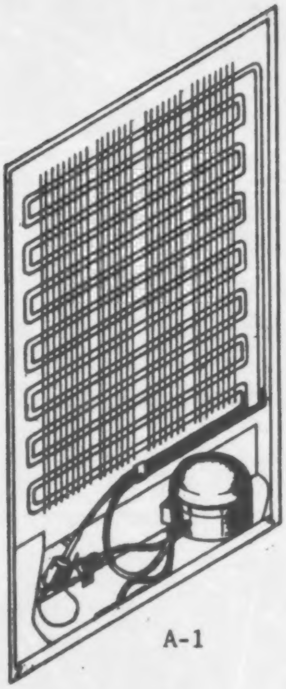
L-1 Job Sheet REF-20a
L-2 ____
L-3 ____
L-4 ____
L-5 ____
L-6 ____
L-7 ____
L-8 ____
L-9 ____

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 ____
C-4 ____
C-5 ____
C-6 ____
C-7 ____
C-8 ____
C-9 ____

Assignment Sheet REF-20a

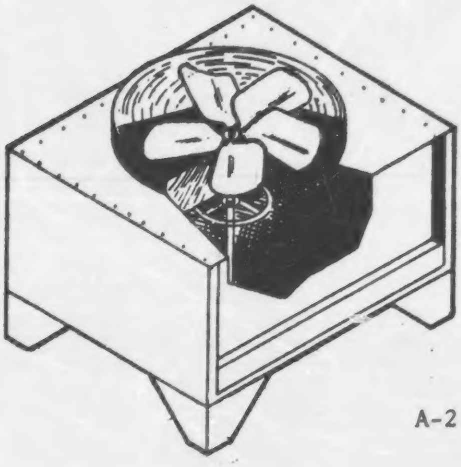
Using the drawings shown below write in the type condenser below each drawing. Also write a brief description of the purpose and operation of each condenser.



A-1

Type

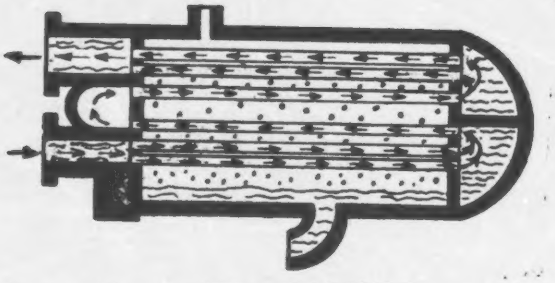
Description



A-2

Type

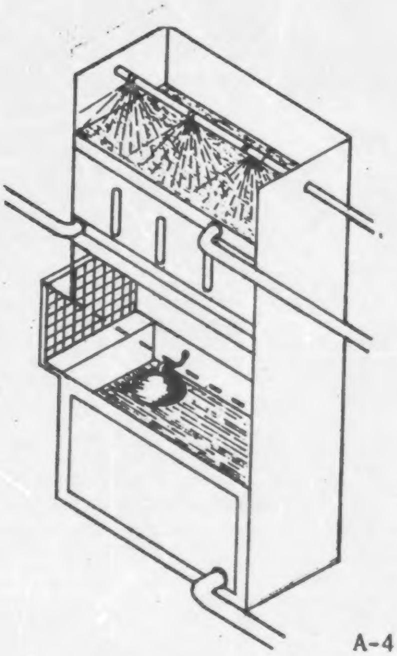
Description



A-3

Type______________________________

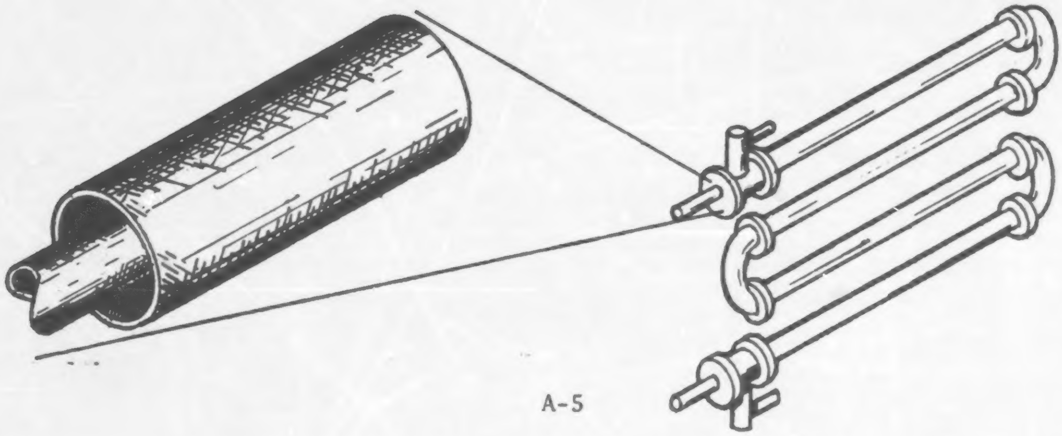
Description__________________________



A-4

Type______________________________

Description__________________________



A-5

Type______________________________

Description__________________________

Procedure:

1. Consult with instructor to determine which refrigeration unit will be used. Be sure unit is disconnected from power source.
2. Secure the proper tools needed for the removal and installation of a condenser.
3. Remove refrigerant from the system, observing all safety precautions learned in previous lessons.
4. Remove condenser by removing hold down screws and either cut the tubing or unsolder the joints. If you are uncertain in the use of the tube cutter or soldering equipment refer to the previous lesson on these subjects.
5. After removal of condenser, inspect for cleanliness, crimped tubing and bent fins.
6. When satisfied with the condition of the condenser re-install in the reverse order of removal. Any problems encountered should first be corrected by reviewing previous lessons or consulting with the instructor.
7. Evacuate system, charge and leak test unit in accordance with applicable manuals.
8. Start unit and check operation in accordance with manuals.
9. Clean tools, equipment and work area.
10. Have instructor check your completed work.
11. Return all tools and equipment to the tool room.

MAJOR BLOCK Refrigeration **NAME**

TASK Troubleshooting

UNIT Applying Principles and Uses of the Evaporator **TIME (est.)** **(act.)**

UNIT NO REF-21

OBJECTIVE(S)

To identify and replace a faulty evaporator.

START → W-1 W-2 C-1 W-3 L-1 C-2

WRITTEN ASSIGNMENT(S)

W-1 Text Assignment REF-21a
W-2 Assignment Sheet REF-21a
W-3 Text Assignment REF-21b
W-4
W-5
W-6
W-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-21a
L-2
L-3
L-4
L-5
L-6
L-7
L-8
L-9

AUDIOVISUAL(S)

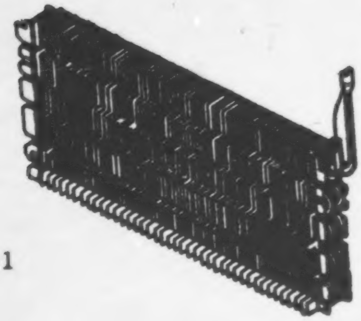
A-1
A-2
A-3
A-4
A-5
A-6
A-7

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3
C-4
C-5
C-6
C-7
C-8
C-9

Assignment Sheet REF-21a

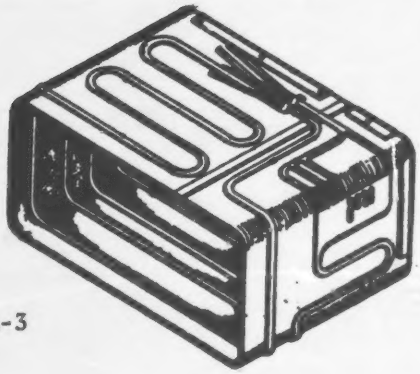
Using the drawings shown below write in the type evaporator below each drawing. Also, write a brief description of the purpose and operation of each evaporator.



A-1

Type ________________

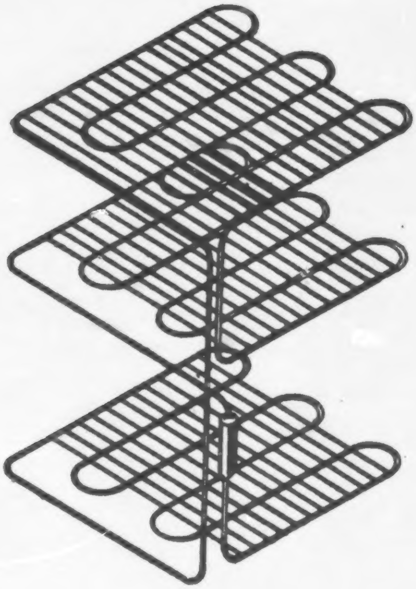
Description ________________
____
____
____



A-3

Type ________________

Description ________________
____
____
____



A-2

Type ________________

Description ________________
____
____
____

PROCEDURE:

1. Consult with instructor to determine which refrigeration unit will be used. Be sure unit is disconnected from power source.
2. Secure the proper tools needed for the removal and installation of an evaporator.
3. Remove refrigerant from system, observing all safety precautions learned in previous lessons.
4. Remove evaporator by removing all attaching screws and either cut the tubing or unsolder the joints. If you are uncertain in the use of the tubing cutter or soldering equipment, refer to the previous lesson on these subjects.
5. After removal of evaporator, inspect for cleanliness, crimped tubing and bent fins.
6. When you are satisfied with the condition of the evaporator, re install it in the reverse order of removal. Any problems encountered should be corrected by reviewing previous lessons on the particular subject or consulting with the instructor.
7. Evacuate system charge and leak test unit in accordance with manufacturer's service manuals.
8. Start unit and check operation in accordance with manual.
9. Clean tools, equipment and work area.
10. Have your instructor check your completed work.
11. Return all tools and equipment to the tool room.

MAJOR BLOCK Refrigeration **NAME** ____

TASK Troubleshooting

UNIT Troubleshooting an automatic expansion valve **TIME (est.)** ____ **(act.)** ____

UNIT NO REF-22

OBJECTIVE(S)

Identify, troubleshoot, and install an automatic expansion valve.

START ➡ W-1 ▷ W-2 ▷ C-1 ▷ L-1 ▷ C-2 ▷ L-2 ▷ C-3 ▷ W-3 ▷ C-4 ▷ ▷ ▷ ▷ ▷ ▷ ▷ ▷ ▷ ▷ ▷ ▷ ▷ ▷ ▷ ▷ ▷ ▷

WRITTEN ASSIGNMENT(S)

W-1 Text Assignment REF-22a
W-2 Assignment Sheet REF-22a
W-3 Assignment Sheet REF-22b
W-4 ____
W-5 ____
W-6 ____
W-7 ____

AUDIOVISUAL(S)

A-1 ____
A-2 ____
A-3 ____
A-4 ____
A-5 ____
A-6 ____
A-7 ____

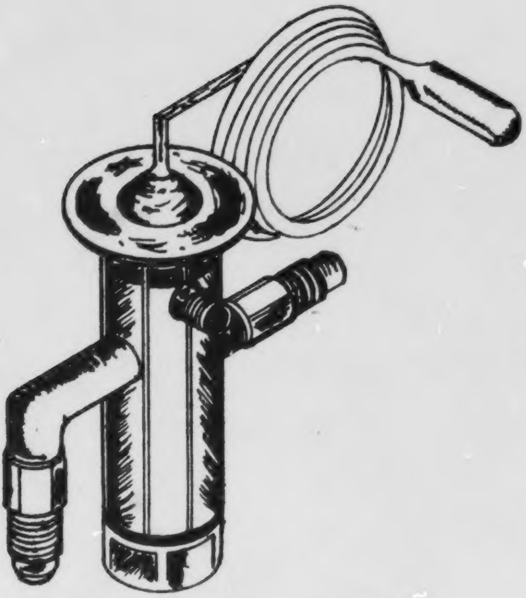
LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-22a
L-2 Job Sheet REF-22b
L-3 ____
L-4 ____
L-5 ____
L-6 ____
L-7 ____
L-8 ____
L-9 ____

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 Instructor Check
C-5 ____
C-6 ____
C-7 ____
C-8 ____
C-9 ____

1. By using the drawings of the two types of expansion valves write in the type valve and give a brief description of how it controls the temperature of the refrigeration unit.



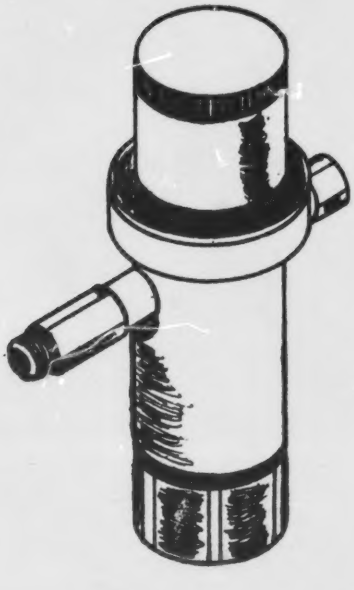
Type Valve ______________

Description ______________

____

____

____



Type Valve ______________

Description ______________

____

____

____

1. Consult with the instructor to determine which refrigeration unit will be used and record serial number below.
2. Secure proper tools and manuals needed for checking the operation of an automatic expansion valve.
3. Start unit and operate until system is established.
4. Make operational checks on the expansion valve in accordance with manufacturer's manual and explain any problem which may exist. Use the space provided below.
5. Contact instructor and explain the procedure used in checking out the expansion valve.
6. Clean tools, equipment, work area and return items to tool room.

Unit Serial Number: ____________________

Existing Problems: ____

____

____

____

____

____

1. Consult with the instructor to determine which refrigeration unit will be used and record the unit serial number below. Make sure the unit has been disconnected from its power source.

2. Secure the proper tools and equipment for the removal and installation of an expansion valve.

3. Remove all refrigerant from the system while observing all safety precautions learned in previous lessons.

4. Remove expansion valve by loosening attaching nuts or unsoldering refrigerant lines. Do not apply excessive heat while unsoldering lines; this can damage the valve.

5. Inspect valve and record below any problems found. Reinstall valve or new replacement.

6. Evacuate the system, charge and leak test the unit according to the appropriate procedures for that equipment.

7. Start the unit and check its operation according to the manufacturer's recommendation.

8. Ask the instructor to check the completed work.

9. Clean tools, equipment and work area and return equipment to the appropriate area.

Unit Serial Number: ____________________

Existing Problems: ____

____

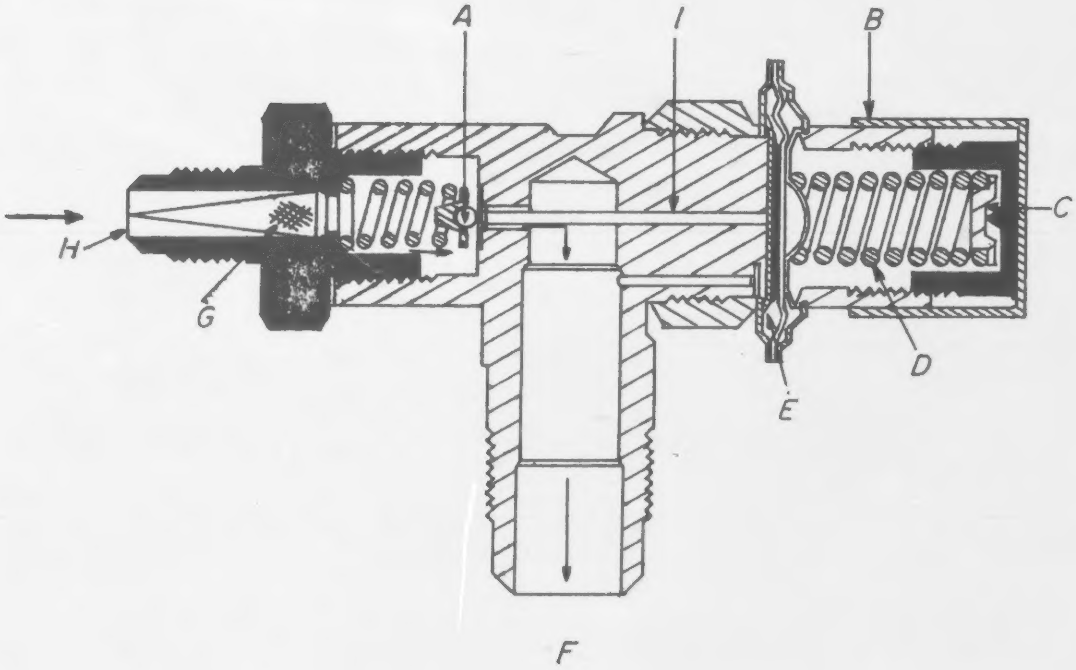
____

____

____

Troubleshooting an Automatic Expansion Valve

1. Using the drawing below, list the names of the parts of an Automatic Expansion valve after the corresponding numbers.



A. ______________________________

B. ______________________________

C. ______________________________

D. ______________________________

E. ______________________________

F. ______________________________

G. ______________________________

H. ______________________________

I. ______________________________

MAJOR BLOCK Refrigeration **NAME** ____

TASK Troubleshooting

UNIT Applying principles of troubleshooting capillary tubes **TIME (est.)** ____ **(act.)** ____

UNIT NO. REF-23

OBJECTIVE(S)

Identify, remove and replace a faulty capillary tube.

START ➡ W-1 W-2 L-1 C-1 C-2

WRITTEN ASSIGNMENT(S)		**AUDIOVISUAL(S)**	
W-1	Text Assignment REF-23a	**A-1**	
W-2	Text Assignment REF-23b	**A-2**	
W-3		**A-3**	
W-4		**A-4**	
W-5		**A-5**	
W-6		**A-6**	
W-7		**A-7**	

LABORATORY ASSIGNMENT(S)		**CHECKPOINT(S)**	
L-1	Job Sheet REF-23a	**C-1**	Instructor Check
L-2		**C-2**	Instructor Check
L-3		**C-3**	
L-4		**C-4**	
L-5		**C-5**	
L-6		**C-6**	
L-7		**C-7**	
L-8		**C-8**	
L-9		**C-9**	

1. Secure the proper tools and equipment needed for the removal and installation of a capillary tube.
2. Consult with your instructor to determine which refrigeration unit will be used. Record the serial number in the space below.
3. Insure unit is disconnected from power source and remove refrigerant from system. Practice all safety precautions learned in previous lesson. Any questions should be discussed with instructor immediately.
4. After all refrigerant has been removed, cut or unsolder tubing at the beginning and end of capillary tube.
5. After removal of capillary tube, inspect for crimped tubing and/or obstruction within the tube. Measure exact length and inside diameter and record below.
6. When you are satisfied with the condition of the capillary tube, reinstall or replace with new tubing of the exact length and diameter in the reverse order of removal.
7. Evacuate system, charge and leak test unit in accordance with applicable manuals.
8. Start unit and check operation in accordance with manuals.
9. Clean up work area and have your instructor check your work.

Unit S/N ____________________________

Length of capillary tube_____________

Inside diameter of tube _____________

MAJOR BLOCK Refrigeration **NAME** ____________

TASK Troubleshooting

UNIT Troubleshooting a thermostatic expansion valve **TIME (est.)** ________ **(act.)** ________

UNIT NO REF-24

OBJECTIVE(S)

Identify, troubleshoot, and install a thermostatic expansion valve.

START ➔ W-1 W-2 C-1 L-1 C-2 L-2 C-3

WRITTEN ASSIGNMENT(S)

W-1 Text Assignment REF-24a
W-2 Assignment Sheet REF-24a
W-3 ____________
W-4 ____________
W-5 ____________
W-6 ____________
W-7 ____________

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-24a
L-2 Job Sheet REF-24b
L-3 ____________
L-4 ____________
L-5 ____________
L-6 ____________
L-7 ____________
L-8 ____________
L-9 ____________

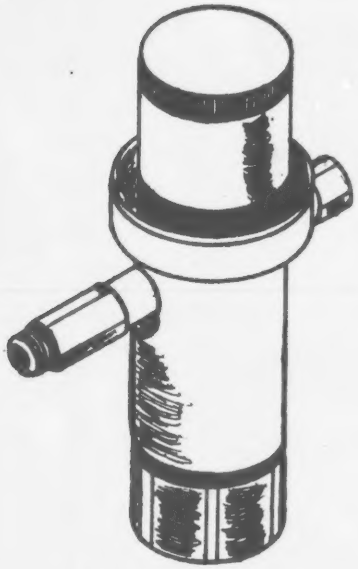
AUDIOVISUAL(S)

A-1 ____________
A-2 ____________
A-3 ____________
A-4 ____________
A-5 ____________
A-6 ____________
A-7 ____________

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 ____________
C-5 ____________
C-6 ____________
C-7 ____________
C-8 ____________
C-9 ____________

I. By using the drawings of the two types of expansion valves write in the type valve and give a brief description of how it controls the temperature of the refrigeration unit.



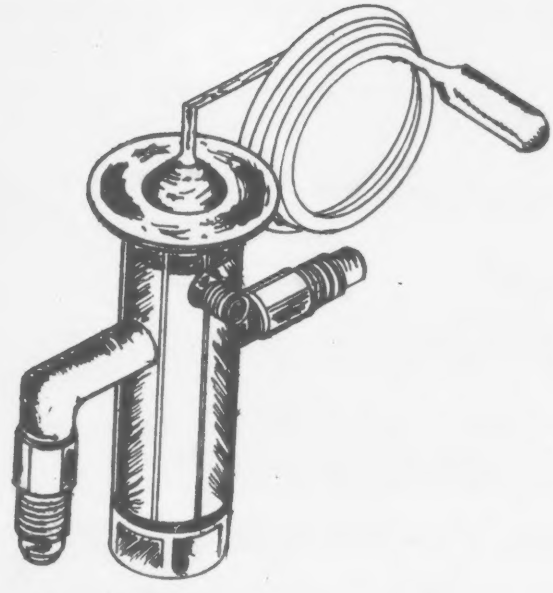
Type Valve ________________

Description ________________

____

____

____



Type Valve__________________

Description ________________

____

____

____

1. Consult with the instructor to determine which refrigeration unit will be used and record serial number below.
2. Secure proper tools and manuals needed for checking the operation of a Thermostatic Expansion Valve (TEV).
3. Start unit and operate until system is established.
4. Make operational checks on the expansion valve in accordance with manufacturer's manual and explain any problem which may exist. Use the space provided below.
5. Contact instructor and explain the procedure used in checking out the expansion valve.
6. Clean tools, equipment, work area and return items to tool room.

Unit Serial Number: ____________________

Existing Problems: ____

____

____

____

____

____

1. Consult with the instructor to determine which refrigeration unit will be used and record the unit serial number below. Make sure the unit has been disconnected from its power source.

2. Secure the proper tools and equipment for the removal and installation of an expansion valve.

3. Remove all refrigerant from the system while observing all safety precautions learned in previous lessons.

4. Remove expansion valve by loosening attaching nuts or unsoldering refrigerant lines. Do not apply excessive heat while unsoldering lines; this can damage the valve.

5. Inspect valve and record below any problems found. Reinstall valve or new replacement.

6. Evacuate the system, charge and leak test the unit according to the appropriate procedures for that equipment.

7. Start the unit and check its operation according to the manufacturer's recommendation.

8. Ask the instructor to check the completed work.

9. Clean tools, equipment and work area and return equipment to the appropriate area.

Unit Serial Number: ____________________

Existing Problems: ____

____

____

____

____

MAJOR BLOCK Refrigeration **NAME** ____

TASK Troubleshooting

UNIT Troubleshooting the Refrigeration System **TIME (est.)** ____ **(act.)** ____

UNIT NO. REF-25

OBJECTIVE(S)

Safely troubleshoot and repair the refrigeration system

START → L-1 → C-1 → L-2 → C-2 → L-3 → C-3

WRITTEN ASSIGNMENT(S)

W-1 ____
W-2 ____
W-3 ____
W-4 ____
W-5 ____
W-6 ____
W-7 ____

AUDIOVISUAL(S)

A-1 ____
A-2 ____
A-3 ____
A-4 ____
A-5 ____
A-6 ____
A-7 ____

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-25a
L-2 Job Sheet REF-25b
L-3 Job Sheet REF-25c
L-4 ____
L-5 ____
L-6 ____
L-7 ____
L-8 ____
L-9 ____

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 ____
C-5 ____
C-6 ____
C-7 ____
C-8 ____
C-9 ____

Procedure:

1. Consult with the instructor to determine which refrigeration unit will be used.

2. Secure proper test equipment and tools needed for troubleshooting the system.

3. Use troubleshooting guide published by manufacturer of unit or refer to Chapter 23 of Refrigeration and Air Conditioning (Text 1) for procedures in troubleshooting.

4. Troubleshoot refrigeration system to determine the cause of the problem. If uncertain of any procedure, refer to previous lesson on that subject.

5. After locating the problem, contact the instructor and explain in detail what the problem is and the procedure used in identifying it.

Procedure:

1. Secure the proper tools to repair the problem located in the previous Job Sheet.
2. Explain to the instructor the procedure used in repairing the problem.
3. Use the manufacturer's manual or Refrigeration and Air Conditioning book (Text 1) for guidance in repairing the unit. If uncertain in any procedure, refer to the previous lesson on that subject.
4. After completing repairs on the unit, contact the instructor and explain the procedure used in repairing the unit and why it was completed in that method.

1. Operate unit to determine its cooling capability.

2. After unit stabilizes, take the following readings:

   Evaporator Inlet Temperature ____________
   Evaporator Outlet Temperature ____________

   Compressor Outlet Pressure ____________
   Compressor Inlet Pressure ____________

3. Using the above readings and a manufacturer's manual, determine if the unit is operating properly.

4. Consult with the instructor and explain how the decision was made in Step 3.

5. If the instructor is satisfied with the above answers, clean the work area and turn in all tools and equipment.

MAJOR BLOCK Refrigeration **NAME** ______

TASK Window Air Conditioning

UNIT Installation of a Window Unit **TIME (est.)** ______ **(act.)** ______

UNIT NO REF-26

OBJECTIVE(S)

Install a window air conditioning unit according to manufacturer's specifications.

START → W-1 → A-1 → L-1 → C-1 → W-2 → L-2 → C-2 → W-3 → C-3

WRITTEN ASSIGNMENT(S)		**AUDIOVISUAL(S)**	
W-1	Information Sheet REF-26a	**A-1**	REF-26a
W-2	Information Sheet REF-26b	**A-2**	
W-3	Information Sheet REF-26c	**A-3**	
W-4		**A-4**	
W-5		**A-5**	
W-6		**A-6**	
W-7		**A-7**	
LABORATORY ASSIGNMENT(S)		**CHECKPOINT(S)**	
L-1	Job Sheet REF-26a	**C-1**	Instructor Check
L-2	Job Sheet REF-26a	**C-2**	Instructor Check
L-3		**C-3**	Instructor Check
L-4		**C-4**	
L-5		**C-5**	
L-6		**C-6**	
L-7		**C-7**	
L-8		**C-8**	
L-9		**C-9**	

Information Sheet REF-26a

Installation of Window Units

It is very important for any piece of equipment to be installed correctly. A window air conditioner is no exception. Proper installation insures a quiet, trouble-free operation of a good air conditioner. Installation of the window unit requires the following list of tools:

1. Hacksaw
2. Screwdrivers (assorted)
3. Hacksaw
4. Nutdrivers
5. Hammer
6. Adj. wrench 6" and 8"
7. Handsaw
8. Screw assortment
9. Permagum
10. Drill
11. Knife
12. Sidecutters

Most new units will have detailed instructions for installation. However, there are situations where the manufacturer's directions are not available. The following slide set is for general applications and can be applied to most any installation job.

The instructor will assign a window air conditioner to inspect. Record the necessary information below and tag the following parts:

1. evaporator
2. condenser
3. fan
4. filter
5. chassis
6. compressor

Unit Serial Number ______________________

Comments:

Before installing the W/AC it is necessary to recognize the cabinet parts identified by the manufacturer. The window part names must also be memorized. These are shown in Figures A and B.

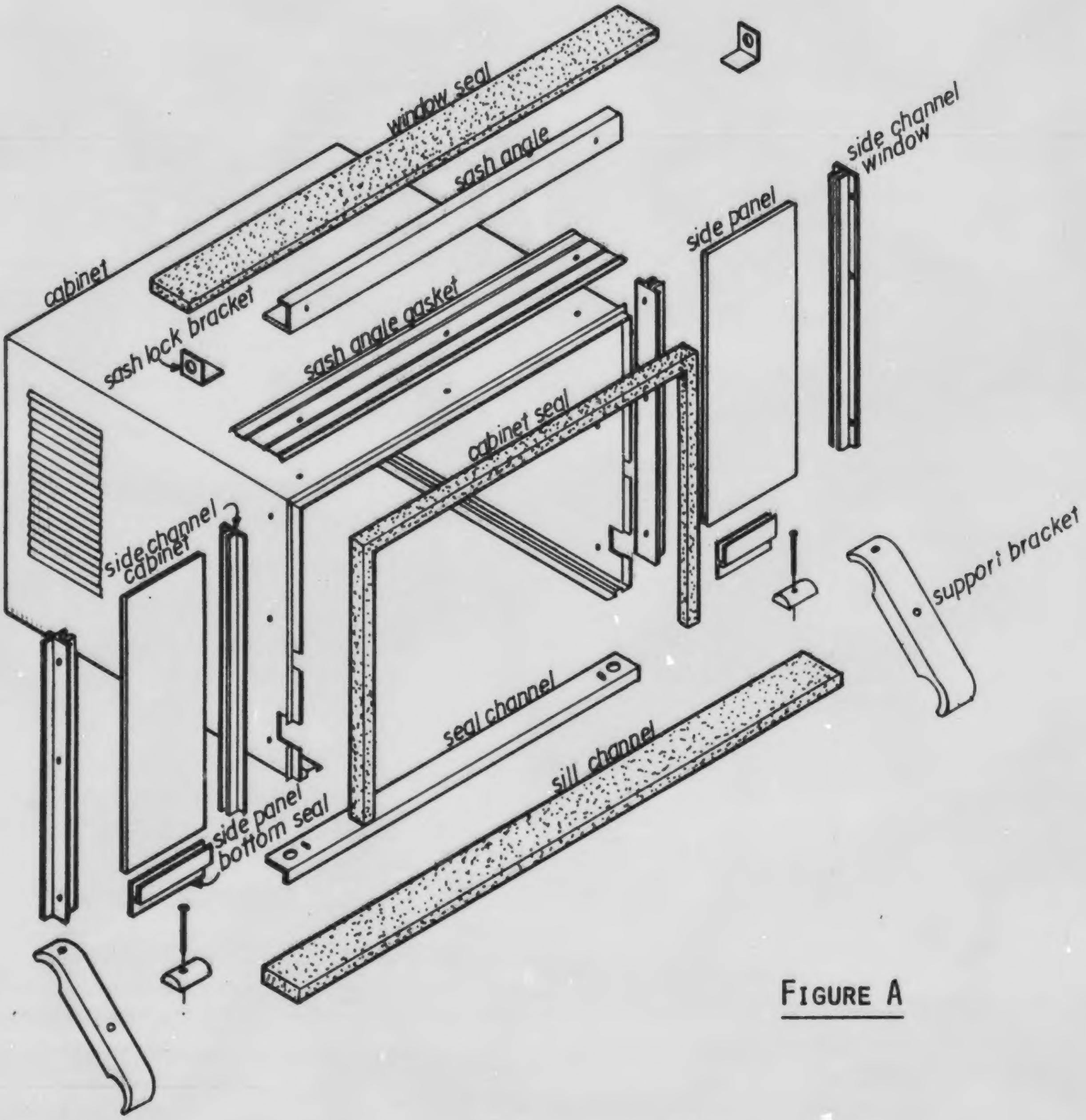


FIGURE A

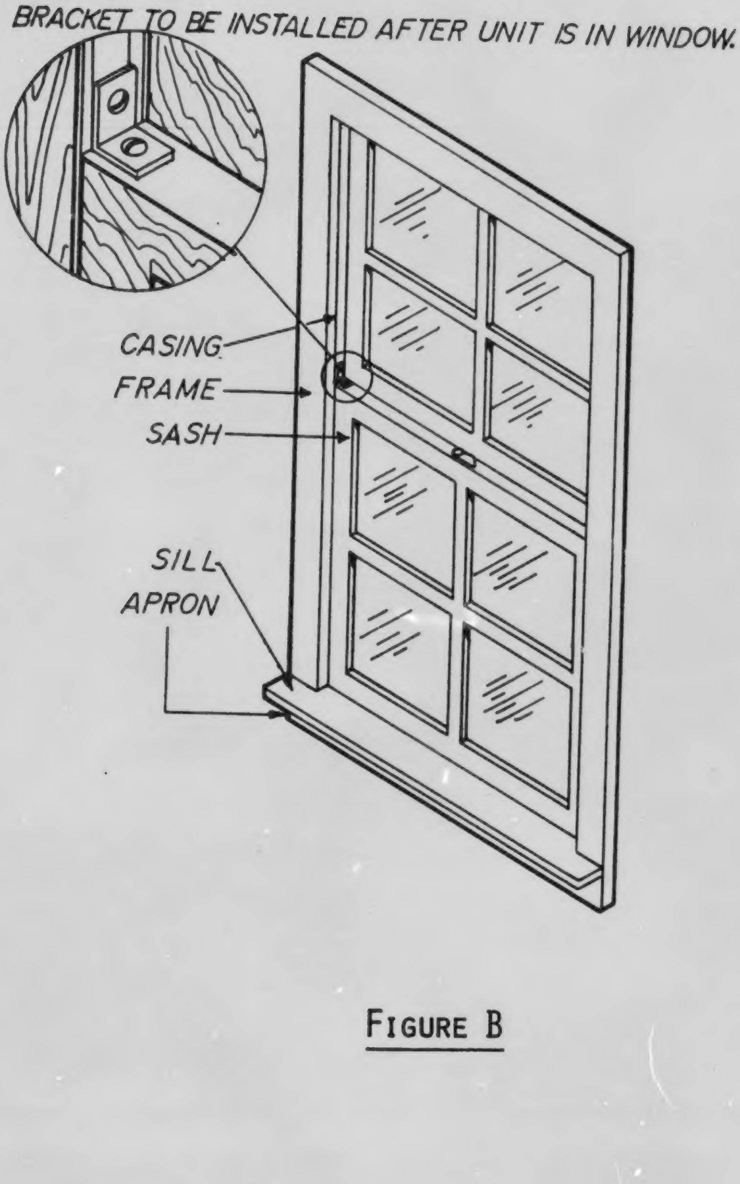

BRACKET TO BE INSTALLED AFTER UNIT IS IN WINDOW.
CASING
FRAME
SASH
SILL
APRON

FIGURE B

The instructor will assign a W/AC that contains the installation instructions. Read the instructions carefully and install the W/AC in a mock-up window.

Observe the following points:

1. Adequate wiring is available.
2. Unit must have a 1/8" to 3/8" drop from front to back. This insures condensate water will drain to outside.
3. Unit must be secure.
4. Window must be blocked from opening.
5. No air leaks around A/C.
6. Check for filter
7. Make sure customer understands operation.

The following is a list of items that should be discussed with the customer before considering the job complete.

1. Tell the customer to wait 5 minutes before cutting W/AC back on after cutting it off as it will blow fuses or damage the unit.

2. The filters must be cleaned at least once a month. (Never run without filter).

3. Oil fan motor once a year.

4. Keep hedges and bushes clear of outside coil.

5. Explain reason for using time-delay fuse.

6. Advise customer to cover the outside section of the A/C during the winter.

MAJOR BLOCK Refrigeration **NAME**

TASK Window Air Conditioners

UNIT Performing Pre-Season Start Up **TIME (est.)** **(act.)**

UNIT NO REF-27

OBJECTIVE(S)

Inspect and perform a pre-season start up for an air conditioning window unit.

START ➜ W-1 A-1 W-2 C-1 L-1 C-2

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-27a
W-2 Assignment Sheet REF-27a
W-3
W-4
W-5
W-6
W-7

AUDIOVISUAL(S)

A-1 Slide Set REF-27a
A-2
A-3
A-4
A-5
A-6
A-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-27a
L-2
L-3
L-4
L-5
L-6
L-7
L-8
L-9

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3
C-4
C-5
C-6
C-7
C-8
C-9

What is pre-season start up?

Pre-season start up is preventive maintenance procedure. This preventive maintenance assures the customer of maximum cooling and maximum life of their window unit.

When should pre-season start up be performed?

Preventive maintenance should be performed in early spring or before the unit is used for the next cooling season.

Can customers perform pre-season start up?

Yes! To some degree they can. If the service technician informs the customer how to clean or change the filter, oil the fan motor, and wash out the coils with water hose, the customer can extend the life of the unit as well as get maximum cooling for each watt of electricity used.

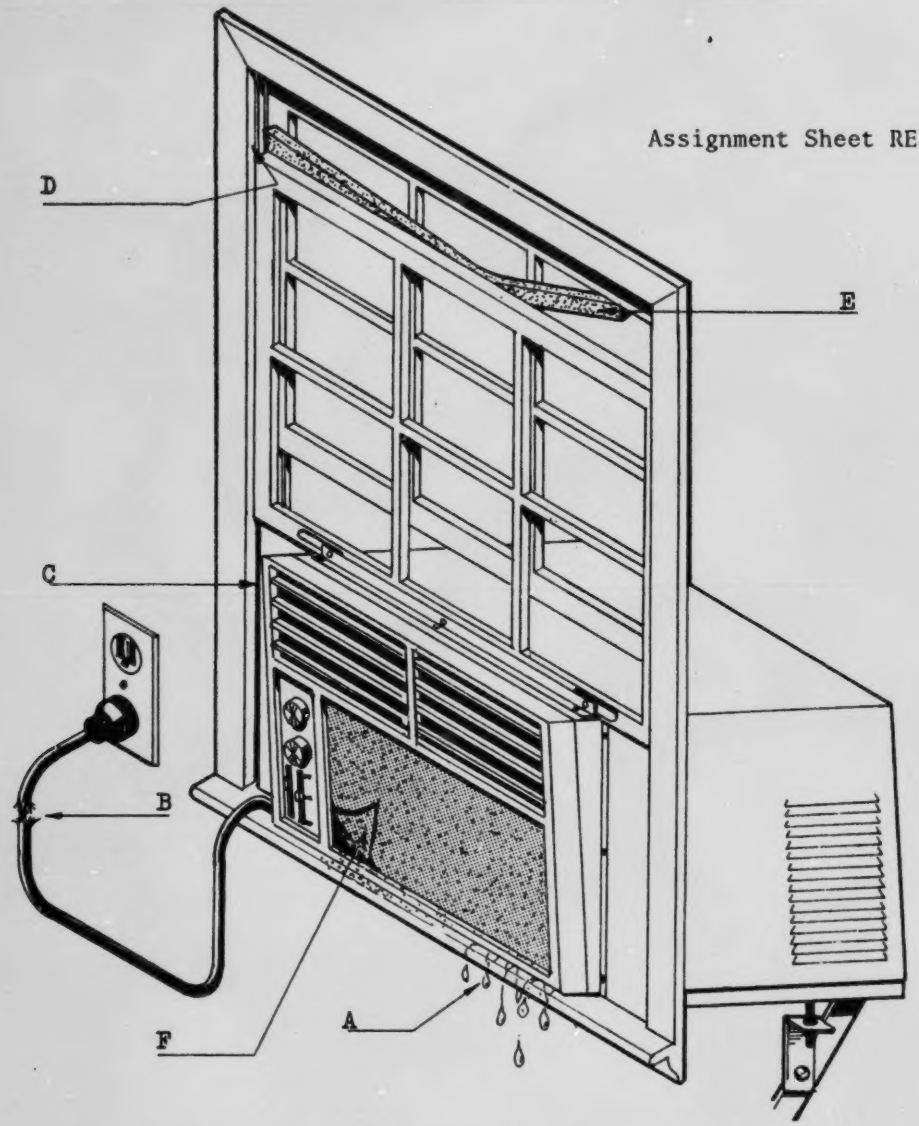


FIGURE A

After viewing AV-REF-28a list below what you think is wrong with the above air conditioner.

A -

B -

C -

D -

E -

F -

Using a mounted, serviceable window air conditioning unit and the following check list perform the pre-season service in the order prescribed.

PROCEDURE	CHECKED		WORK PERFORMED
	ok	needs repair	
1. Start up unit prior to inspection			
2. Visual Inspection			
a. rotten wood around window			
b. cracks in seals and windows			
c. water leaks			
d. dirty filter			
e. dirty coils			
f. tilt of unit			
g. condition of unit braces			
h. condition of receptacle and cord			
3. Perform Operations			
a. remove unit			
b. oil fan motor			
c. wrap fan motor with plastic			
d. clean coils			
e. straighten fins			
f. clean evaporator drains			
g. repair bracing			
h. tilt unit to outside (1/8 to 3/8 inch)			
i. repair window (rotten wood)			
j. repair or replace damaged and/or missing seals			
k. re-install unit			
l. clean filter			
m. repair cord			
n. repair receptacle			
o. start up and run			
p. check inlet and outlet temperatures			
q. repair water leaks			
r. clean area			
s. inform customer of maintenance procedures			

COMMENTS

MAJOR BLOCK Refrigeration **NAME** ________

TASK Window Air-Conditioners

UNIT Troubleshooting Burnout **TIME (est.)** ______ **(act.)** ______

UNIT NO REF-28

OBJECTIVE(S)

START → W-1 → A-1 → L-1 → C-1 → W-2 → A-2 → L-2

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-28a
W-2 Information Sheet REF-28b
W-3
W-4
W-5
W-6
W-7

AUDIOVISUAL(S)

A-1 Slide/Script REF-28a
A-2 Slide/Script REF-28a
A-3
A-4
A-5
A-6
A-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-28a
L-2 Job Sheet REF-28b
L-3
L-4
L-5
L-6
L-7
L-8
L-9

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3
C-4
C-5
C-6
C-7
C-8
C-9

Compressor Burnout

A compressor burnout exists when a compressor fails to operate electrically due to open windings, grounded windings, open internal overload, shorted windings or any combination of these problems.

There are many reasons for compressor burnout, but some of the more common are:

1. Lightning which causes a very high voltage surge, and literally melts the windings and insulation.
2. Problems due to faulty electrical components that control the compressor may exist (capacitor, overload, relay, oversized fuses).
3. Low voltage due to improper installation (wiring too small), or bad contact in switch receptacle.
4. Insufficient cooling to compressor windings due to low charge and high head pressure.
5. Faulty compressor windings or bad bearings in motor.

The instructor will provide three compressors, the student will determine a faulty compressor from a good one. If additional information is needed, review Slide Set REF-29a.

Tools Needed:

1. VOM
2. Compressor test cord
3. Amprobe
4. File
5. Screw driver

Equipment Needed (three compressors):

1. One will be grounded.
2. One will have open windings.
3. One will be operational.

Procedures:

1. Check all three compressors for grounded windings with VOM Meter. Set meter on RX100 and ground one lead to the dome, be sure to scratch a bare place, touch each terminal with the other lead. Any reading suggests a bad compressor.
2. Check the compressor for open windings. Set meter on RX1. Check and record continuity on all three terminals.
3. Determine the start, common, and run terminals of the compressor that checked good with VOM and start the compressor.
4. Record your findings on the following page.

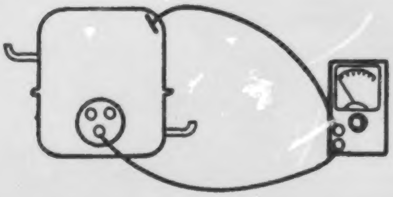
Please give the following information on your work.

1. Was the compressor grounded to the dome?

Compressor #1 ________

Compressor #2 ________

Compressor #3 ________

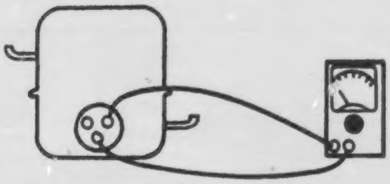


2. Did the compressor have a open winding?

Compressor #1 ________

Compressor #2 ________

Compressor #3 ________

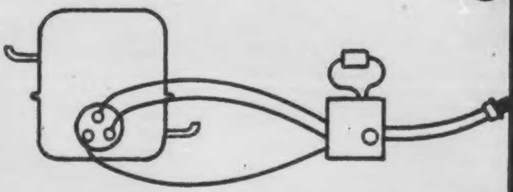


3. Would the compressor start?

Compressor #1 ________

Compressor #2 ________

Compressor #3 ________



Please circle:

Compressor #1	Compressor #2	Compressor #3
Good	Good	Good
Bad	Bad	Bad

When compressor burnout occurs, the system becomes contaminated with carbon and sludge. Also, in the presence of heat and moisture hydrochloric acid will form. Oil in this conditon is termed "acidic". If the system is not thoroughly flushed out, this acid will cause the insulation on the windings of a new compressor to rapidly deteriorate and short circuit the unit.

Do not touch the oil from a burned out unit, as it will cause severe acid burns. Do not allow the oil to run on the floor. Trap the oil in a suitable container. Burned out compressors will have a very unpleasant odor. If there is no odor present and the oil is clean, chances are the compressor did not burn out.

Burned out compressors are not repaired in the field. The compressor is replaced with a new or rebuilt unit. The following audio-visual will detail the replacement job.

Replacement of a Burned Out Compressor

1. The instructor will assign a unit on which the compressor will be replaced.

2. Follow the procedures and replace the compressor in a window air-conditioner as if it were a severe burnout.

3. Bleed refrigerant by cutting a small cut with a hack saw on the compressor stub or on the strainer coming from condensor. (Be sure and put a rag around cut to catch the oil. The oil is potentially dangerous because of acid content. Do not allow it to touch the skin).

4. Remove wiring from the compressor during bleed off.

5. After making sure that the unit has been bled and the system has no pressure on it, unbraze the lines from the compressor. (Be sure not to stand over or directly in front of the line to be removed. (Oil may squirt out which is burning. Also deadly phosgene gas may engulf you.)

6. Remove mounting bolts, brackets, etc.

7. Mash lines on old compressor and seal.

8. Lift out compressor. (Be careful not to spill oil or touch the oil if the compressor is not sealed.)

9. Set new compressor in place. (Do not hook up lines.)

10. Remove drier or filter and capillary tubes by cutting from line with tubing cutter or hack saw.

11. Flush R-12 through the evaporator and condensor. This procedure needs to be done in a well ventilated area and with the instructors help.

12. Install new capillary tube(s). Use capillary sizing chart to determine proper size. (Depending on the severity of the burnout, capillary tubes may or may not need to be removed).

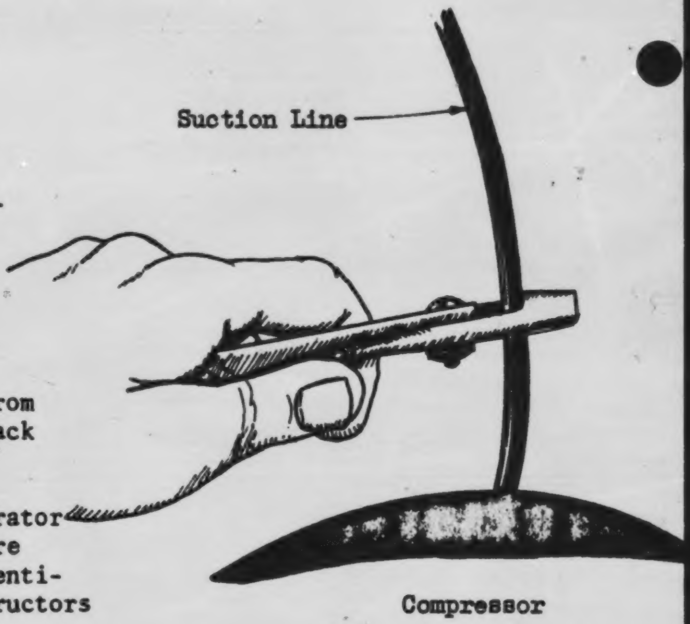


FIGURE A

13. Install new filter or oversized filter dryer in the liquid line.
14. Re-install all lines.
15. Leak check the lines.
16. Evacuate the system.
17. Install all wiring.
18. Charge the system.
19. Check for proper operation.

MAJOR BLOCK Refrigeration **NAME**

TASK Window Air Conditioners

UNIT Evacuating and Charging **TIME (est.)** **(act.)**

UNIT NO REF-29

OBJECTIVE(S)

Evacuate and charge window air conditioners.

START ➡ W-1 ▷ A-1 ▷ W-2 ▷ L-1 ▷ C-1 ▷ A-2 ▷ L-2 ▷ C-2 ▷ L-3 ▷ C-3 ▷

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-29a
W-2 Text Assignment REF-29a
W-3
W-4
W-5
W-6
W-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-29a
L-2 Job Sheet REF-29b
L-3 Job Sheet REF-29c
L-4
L-5
L-6
L-7
L-8
L-9

AUDIOVISUAL(S)

A-1 Slide/Script REF-29a
A-2 Slide/Script REF-29b
A-3
A-4
A-5
A-6
A-7

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4
C-5
C-6
C-7
C-8
C-9

A window unit system must be evacuated anytime a repair to the refrigeration cycle is performed or refrigerant is replaced.

Window units do not normally work at low enough temperatures to freeze moisture in the unit and restrict refrigerant flow. Occasionally, however, this condition will exist. Moisture is a continuous problem in the refrigeration industry, because it contaminates the oil and causes corrosion. Acids are formed which will deteriorate metals and compressor windings. To remove these dangers, be sure that equipment and components are kept clean and always evacuate the system when repair work is performed on the refrigeration cycle.

The triple evacuation method is the fastest and easiest way to evacuate the system. For window air-conditioners it is the most practical.

The following slides will demonstrate this method.

Evacuating a Window Air-Conditioner

1. The instructor will assign a window unit for this activity.
2. Install process valve on suction and discharge lines.
3. Install service manifold.
4. Evacuate system using triple evacuation method.
5. Put a holding charge on unit. (This means put enough refrigerant in the system to bring the system's internal pressure up to 0 (zero) pounds per square inch guage.)

*Do not charge the system at this point.

Charge a unit using the temperature, pressure, and touch method.

1. Gain access to the unit.
2. Make any repairs needed and leak check the refrigeration lines.
3. Evacuate the system.
4. Pressurize up to 70 to 80 pounds per square inch guage of proper refrigerant.
5. Start up air-conditioner.
6. Let refrigerant in through low side in gas state. (Tank may need to be put in warm water.) Never heat tank with a torch.
7. Look at where the cap tube enters the evaporator. Frost should be visible at first.
8. Keep adding refrigerant to low side in gas state. When frost disappears from evaporator on the entire coil, the unit is almost fully charged.
9. The suction pressure should climb slowly and continuously while the unit is charging. (If the system stays in a vacuum, it is likely that a restriction exist.)
10. When all the frost has disappeared from the evaporator, feel the suction line. It should be fairly cool to the touch. The suction line surface should have moisture all the way to the compressor.
11. Check your temperature drop across the coil. If the temperature drop is from 15 to 20 degrees Fahrenheit drop, the unit is probably fully charged. Remember, the most possible temperature drop is desirable.
12. Close and seal the unit.

NOTE: When charging a window air-conditioner or any refrigeration system, don't get in a hurry. Take your time and use your senses of touch and sight to guide you.

Charge a unit with the Dial-a-charge method. Use the following procedures to guide this activity:

1. Determine the window air-conditioner charge to the ounce.
2. Put approximately 8 ounces more refrigerant in Dial-a-charge than needed.
3. Let Dial-a-charge pressure equalize while evacuating unit.
4. Charge window air-conditioner with holding pressure from Dial-a-charge.
5. Start the window air-conditioner.
6. Charge the unit with gas vapor from Dial-a-charge.
7. Put the exact charge in the unit.
8. Check temperature drop.
9. Close and seal the unit.

NOTE: If a suction line filter or extra tubing has been added, an exact charge cannot be determined. In this case you would have to use temperature, pressure, touch method.

MAJOR BLOCK Refrigeration **NAME**

TASK Window Air Conditioner

UNIT Troubleshoot Fan and Fan Motors **TIME (est.)** **(act.)**

UNIT NO REF-30

OBJECTIVE(S)

Troubleshoot and replace the fan and fan motor on a window air-contioning unit.

START → W-1 → W-2 → C-1 → W-3 → A-1 → W-4 → L-1 → C-2 → L-2 → C-3 → A-2 → L-3 → C-4

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-30a
W-2 Assignment Sheet REF-30a
W-3 Information Sheet REF-30b
W-4 Text Assignment REF-30a
W-5
W-6
W-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-30a
L-2 Job Sheet REF-30b
L-3 Job Sheet REF-30c
L-4
L-5
L-6
L-7
L-8
L-9

AUDIOVISUAL(S)

A-1 Slide Set REF-30a
A-2 Slide Set REF-30b
A-3
A-4
A-5
A-6
A-7

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 Instructor Check
C-5
C-6
C-7
C-8
C-9

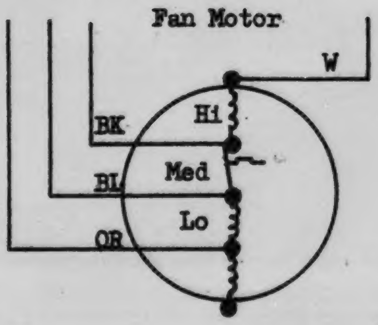
Window air conditioner manufacturers use two types of fan motors in their air conditioning. The shaded pole motor is used because of its simple design and low starting-torque. The permanent split capacitor motor is used because of its relative low cost compared to other motors and its moderate starting-torque.

Manufacturers usually prefer the permanent split capacitor motor because it has slightly more starting power than the shaded pole motor. For this reason more fan speeds are possible. The easiest way to recognize the permanent split-capacitor motor is by checking for a run capacitor. This can usually be identified by reading the schematic of the motor to identify the run capacitor.

Although not preferred as often by manufacturers of window air conditioners, the shaded-pole motor is used extensively where only low starting power is needed. Its simple design permits air-conditioner service technicians to easily diagnose and service problems.

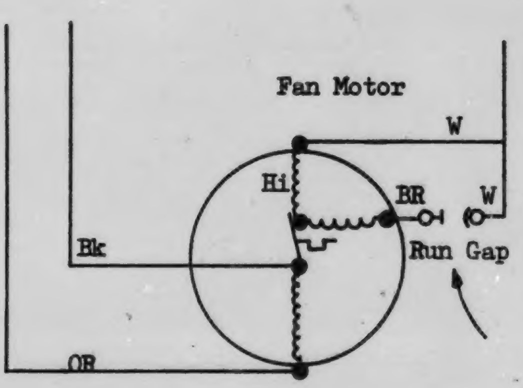
Shaded-pole Motor Schematic

A-1



PSC Motor Schematic

A-2



Assignment Sheet REF-30a

1. The instructor will assign three window units or three fan motors for this activity. Determine whether each motor is a shaded pole or a permanent split capacitor (PSC).

2. Complete the following information for each motor.

	Serial Number	Size/HP	Shaded Pole/PSC
Motor #1	____________	____________	____________
Motor #2	____________	____________	____________
Motor #3	____________	____________	____________

Fan motors usually go bad because of mechanical or electrical failure. Usually mechanical failure is due to bad bearings, a warped shaft, warped end bells, or some other problem not relating to electricity. Electrical failure usually results from open, grounded, or shorted windings.

Many of the problems which occur with an electric motor may be easily identified. Some of the symptoms which might suggest that a motor is defective are:

(a) motor will not start

(b) motor starts but very slow to come up to speed

(c) bad bearings - shaft can be moved in an upward or downwards direction; shaft wobbles

(d) there is arcing in the motor

(e) excessive humming noise

(f) smoke from motor

(g) excessive blown fuses or circuit breaker trips

The following information will be helpful in diagnosing fan motor troubles.

1. Look on the motor or on the unit for an electrical wiring diagram.
2. Determine what wires go to each component and identify them by color or number.
3. Carefully zero the ohmmeter on the R x 1 position.
4. When you test a motor winding, you should consider the following:
    (a) If the ohmmeter goes all the way to zero side of the scale, you probably have a direct short.
    (b) If the ohmmeter stays on infinity, you have an open winding.
    (c) All windings should have a resistance reading, and different speeds will read different resistances.

The instructor will assign a window unit on which motor windings can be checked by the "Direct Test" method.

1. Always check voltage before performing the direct test on the fan motor.

2. Check fan capacitor if applicable. (Only if motor is capacitor start).

3. Disconnect power from unit.

4. Disconnect the fan motor leads (refer to wiring schematic) (Make direct test with fan motor in place and fan blades in the proper position).

5. Place the time-delay fuse into direct test socket (15 amp).

6. Connect leads to the fan motor.

   (a) Connect run lead to main winding lead of the fan motor. (Main winding lead is usually white).

   (b) Connect common lead to high speed lead of the fan motor. (High speed lead is usually black).

   (c) Connect start lead to start winding lead on capacitor start fan motors. (Start winding lead is usually brown).

   (d) Connect ground lead to bare metal component on unit. (If no ground lead is provided add one between wall receptacle "ground" and bare metal component on unit).

   (e) With direct test switched "off," plus power supply leads into the voltage outlet.

   (f) Turn the switch "ON."

   (g) Refer to Information Sheet REF-31b to identify symptoms.

      A. Unit serial number ____________________

      B. Diagnosis ______________________________

      C. Repair needed _________________________

The instructor will assign a window unit on which the fan and the fan motor can be removed. Use the following procedures:

1. Remove the top cover and as many covers as possible to make the motor accessible.

2. Unplug the electrical wires. Notice their numbering system, and how they are connected.

3. If the wires are not numbered, identify them in some way (such as masking tape with numbers hand lettered---remember to remove masking tape when the job is completed).

4. The motor is probably held in position with bolts or clamps. These must be removed.

5. The fan blades may have to be removed to get the motor out.

6. Determine how to remove the fan. Look for set screws or some other type of holding mechanism.

7. Remove the fan motor.

8. Replace the fan motor and reconnect all wiring.

9. Check the motor for proper operation.

MAJOR BLOCK Refrigeration **NAME** ______

TASK Window Air Conditioning

UNIT Troubleshooting Window Air Conditioning (Refrigeration Cycle) **TIME (est.)** ______ **(act.)** ______

UNIT NO REF-31

OBJECTIVE(S) Troubleshoot the refrigeration cycle of a window air conditioner

START ➔ W-1 W-2 A-1 L-1 C-1 W-4 L-2 C-2

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-31a
W-2 Text Assignment REF-31a
W-3 Text Assignment REF-31b
W-4 Information Sheet REF-31b
W-5 ______
W-6 ______
W-7 ______

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-31a
L-2 Job Sheet REF-31b
L-3 ______
L-4 ______
L-5 ______
L-6 ______
L-7 ______
L-8 ______
L-9 ______

AUDIOVISUAL(S)

A-1 Slide Set REF-31a
A-2 ______
A-3 ______
A-4 ______
A-5 ______
A-6 ______
A-7 ______

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 ______
C-4 ______
C-5 ______
C-6 ______
C-7 ______
C-8 ______
C-9 ______

Troubleshooting a Window Air Conditioner Mechanical Refrigeration Cycle

1. What is troubleshooting a window air conditioning refrigeration cycle? Put simply, it is finding what is wrong with the mechanical cooling portion of a window air conditioner and then replacing it.

2. Is it difficult to learn how to troubleshoot the refrigeration cycle? No, if the student has successfully completed and understood the previous units, it is simply checking for what should be happening but isn't.

3. Can I learn how to troubleshoot a window air conditioner? Probably yes, it is really quite simple. The student must study and learn what the window air conditioner should be doing and then take complaints of what it isn't doing and check to see why.

4. What is the most common problem with the refrigeration cycle? Probably, the biggest problem is dirt. If either the evaporator or condenser is dirty and stopped up the unit will not operate properly.

5. How do I troubleshoot a unit? Use good judgement and think things out before tearing something apart. Troubleshooting is learned through experience and this unit is designed to give some basic experience in that regard.

Job Sheet REF-31a

1. The instructor will assign an air conditioner that is working properly.
2. Remove cabinet exposing discharge and suction lines.
3. Plug the unit into proper voltage source and check for proper operation.
4. Record findings where indicated.
5. Replace all equipment and tools.

***REMEMBER TO WATCH WHERE YOU PUT YOUR HANDS!!!

Please circle findings.

1. Suction line temperature	Cool	Warm	Hot
2. Discharge line temperature	Cool	Warm	Hot
3. Condenser discharge air temperature	Cool	Warm	Hot
4. Evaporator discharge air temperature	Cool	Warm	Hot
5. Liquid line temperature	Cool	Warm	Hot

Record findings.

6. Evaporator air drop ________ °F
7. Discharge Pressure ________ PSIG
8. Suction Pressure ________ PSIG
9. Does this unit seem to be cooling? ________
10. Does unit seem to be cooling efficiently? ________
11. Do the coils seem to be dirty? ________
12. In your opinion, is this unit working properly? ________

REFRIGERATION CYCLE COMPLAINTS

Complaint	Possible Causes	Tests-Repairs
1. Compressor runs constantly- will not cycle off	(a) Restriction in line	(a) Check for iced area along capillary or liquid line. Make certain frost is not caused by dirty or blocked evaporator. Test for high current. (Replace cap tube if it is restricted).
	(b) Leak in system.	(b) Check evaporator coil after 10-15 minutes of operation. If not cooling, check for leaks and repair.
	(c) Restricted air flow.	(c) Check each coil for dirt accumulation. Clean if needed.
2. Not enough cooling.	(a) Excessive heat load.	(a) Heat is building up faster than window air conditioner can absorb. Check cooling performance for need of larger unit.
	(b) Not enough ventilation for condenser.	(b) Change location of window air conditioner.

(c) Evaporator/Condenser fans dirty or plugged blocking air flow.	(c) Clean fins (brush, vacuum, clean, etc.
(d) Partial or complete restriction in tubing.	(d) Check for frosted capillary or liquid line. (Make sure coil is not restricted by dirt which would cause frosted evaporator). Check for high running current. If restricted replace.
(e) Bad valves in compressor.	(e) Replace compressor if suction and discharge pressure are very close together. (A compressor that will not pump may have a cool discharge line).

1. Determine (from information given in previous units) whether to enter the refrigeration system.

2. Decide what type of service valves to use. (Remember that it is best to have access to both the high and low sides).

3. Install access valves (according to previous units and manufacturer's recommendations).

4. Write down the gauge pressures before starting the air conditioner. Record both the high side and low side pressure, the drop across the evaporator, and ambient air temperature. Ambient air temperature is the surrounding outside temperature of the condenser.

5. Remember to look over and touch components, checking for anything out of the ordinary.

6. Cut machine off and try and determine what the problem is.

7. Repair the problem.

8. Seal the unit (using previous units as a guide). (Remember to always evacuate a unit after working on refrigeration cycle).

Job Sheet REF-31b

1. The instructor will assign a window air conditioner to work on. There is a problem with the refrigeration cycle. Gain access to the system, record needed data below, and check with troubleshooter's chart to determine possible cause.
2. Describe problem to instructor.
3. Repair problem.

Check	Record	Procedure
1. Evaporator Temp. Drop.	________ °F	Use thermometer
2. Suction line	Frost, CVO (sweating), warm pressure	Touch with fingers
3. Discharge line	warm-hot pressure	Touch lightly
4. Condenser	dirty - clean warm - hot - both	eyesight
5. Evaporator	dirty - clean wet - dry frost - no frost	eyesight
6. Metering device (cap tube)	dry - wet kinks - no kinks warm - cold	eyesight eyesight - touch touch
7. Strainer or dryer (just before cap tube)	dry - wet cold - warm - hot	eyesight touch
8. Compressor	cold - warm - hot noisy - quiet amperage	touch eyesight amprobe (ammeter)
9. Condensate	none - little - lot	eyesight
10. Filter	clean - dirty - none	eyesight

MAJOR BLOCK Refrigeration **NAME**

TASK Window Air Conditioning

UNIT Troubleshooting a Window Air Conditioner Electrical System **TIME (est.)** **(act.)**

UNIT NO REF-32

OBJECTIVE(S)

Locate electrical problems in a window air conditioner.

START → W-1 → A-1 → L-1 → C-1 → W-2 → L-2 → C-2 → W-3 → A-2 → L-3 → C-3

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-32a
W-2 Text Assignment REF-32a
W-3 Information Sheet REF-32b
W-4
W-5
W-6
W-7

AUDIOVISUAL(S)

A-1 Slide Set REF-32a
A-2 Slide Set REF-32b
A-3
A-4
A-5
A-6
A-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-32a
L-2 Job Sheet REF-32b
L-3 Job Sheet REF-32c
L-4
L-5
L-6
L-7
L-8
L-9

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4
C-5
C-6
C-7
C-8
C-9

Approximately 90% of all problems with window air conditioners are electrical. In troubleshooting the window unit there are three areas of learning that must be mastered. They are:

1. Identifying all the part names and functions.
2. Reading wiring diagrams.
3. Checking each component with a meter.

There are only two running parts that use electricity. They are the fan motor and compressor motor. The remainder of the electrical system either controls or protects thest two components. Using knowledge gained from previous units the electrical system can be easily checked.

1. The instructor will assign a window air conditioner to identify components. Record the unit serial number below.

2. Locate and tag the following components:

   a. compressor
   b. fan motor
   c. capacitor
      (1) single type
      (2) dual type
   d. main switch
   e. thermostat
   f. overload

Unit Serial Number________________________________

Reading Wiring Diagrams

1. The instructor will assign a W/AC with a wiring diagram attached.
2. Find the voltage supply lines going to the fan motor and compressor and record color code.
3. Determine which is common, run, and start on the compressor and label.
4. Determine whether the fan motor is shaded pole or a permanent split capacitor type and record below.
5. Determine how many speeds the fan has and what color wire controls that that speed and record below.
6. Find thermostat and overload, and label.
7. Find capacitor and start winding, and label.

Unit Serial Number ____________________

Supply Voltage Color Codes ____

Fan Motor Type ____

Fan Motor Speeds and Color Codes ____

____

____

The following is a "troubleshooting chart" to be used in diagnosing problems that occur in the window air conditioner. As can be seen on the chart, several different defects can cause similar problems. It is the technician's responsibility to identify the correct problem as quickly as possible. You may want to use this chart with the next Job Sheet REF-32c.

WINDOW AIR CONDITIONER - TROUBLESHOOTING CHART

Problem	Possible Cause	Repair or Service Needed
Unit inoperative	a. No power	a. Check for good plug contact, fuses of correct size, and time-delay type.
	b. Low voltage	b. Raise voltage if more than 10% below nameplate rating. Improve wiring and/or use transformer.
	c. Incorrect wiring or defective	c. Check correctness of wiring and connections. Check operation of switches, all thermostats, relays, overload, compressor, fan motor, capacitors, transformers, etc.
Fan runs but compressor does not	a. Incorrect power supply	a. Check for proper voltage.
	b. Defective component or incorrect wiring	b. Check correctness of wiring and connections. Check operation of switches, all thermostats, relays, overload open or shorted starting capacitor, shorted run capacitor.
Compressor runs but fan does not	a. Blower wheel or fan blade binding	a. Check for proper clearances.
	b. Defective component or incorrect wiring	b. Check correctness of wiring and connections. Check operation of all switches, thermostats, de-icer controls, shorted capacitor, defective reactor or fan motor.
	c. Defective reactor or incorrect wiring.	c. Check reactor and wiring

Problem	Possible Cause	Repair or Service Needed
Compressor runs but fan does not (cont'd)	d. Defective controlling relay (remote control models).	d. Check relay and wiring.
No cooling but compressor and fan are operating	a. Air flow restriction	a. Dirty filter. Air passages obstructed.
	b. Compressor not pumping	b. Check for low wattage, restriction, loss of refrigerant, low capacity compressor.
Insufficient cooling - compressor and fan operating	a. Improper air flow	a. Dirty filter. Air passages restricted or obstructed. Exhaust door open. Dirty condenser, evaporator or fans.
	b. Compressor not pumping at full capacity.	b. Check for low wattage, low voltage, low capacity compressor, restriction, loss of refrigerant.
	c. Operating 60 cycle unit on 50 cycle current	c. Advise customer unit is operating normally under these conditions if unit is delivering only 5/6 of 60 cycle operating output.
	d. Low voltage	d. Check power supply.
	e. Improper seals	e. Insulating seals out of place or missing on unit. Doors or windows open.
	f. Improper use	f. Excessive load. Advise customer if load is excessive or installation is incorrect or inadequate. Instruct on proper operation of thermostat and other controls.
	g. Fan motor too slow	g. Check for wrong motor, wrong blower wheel or fan blade. Low voltage - adjust top on reactor (if present). Check for binding of fan blade, blower wheel or motor shaft. Lubricate fan motor.
Compressor stops and starts - too short running time	a. Attempting to start unit too soon after shut off	a. Instruct customer of need for 2-minute wait for pressure equalization
	b. Incorrect voltage	b. Check for proper voltage.

Problem	Possible Cause	Repair or Service Needed
Compressor starts and stops - too short running time (cont'd)	c. Thermostat set too warm	c. Instruct customer.
	d. Defective thermostat	d. Check temperature thermostat and deicer thermostat.
	e. Defective compressor, compressor controlling components, incorrect wiring	e. Check compressor windings, all wiring, overload, relay, starting and/or running capacitor for shorts.
	f. Fan motor too slow	f. Check for wrong motor, wrong blower wheel or fan blade. Low voltage - adjust top on reactor (if present). Check for binding of fan blade, blower wheel or motor shaft. Lubricate fan motor.
House circuit fuses blowing	a. Improper fuses	a. Check for correct size and of time-delay type.
	b. Trying to start unit too soon after shut off.	b. Instruct customer of need for 2-minute wait for pressure equalization
	c. Improper voltage or incorrect wiring.	c. Check power supply, connections, all wiring. Improve wiring and/or use tranformer.
	d. Defective component or incorrect wiring.	d. Check correctness of wiring and connections. Check operation of switches, all thermostats, relays, overload, compressor, fan motor, capacitor, transformer, etc.
Noisy operation	a. Loose parts	a. Check shipping clamps, washers, tubing contact or vibration, loose screws, etc.
	b. Mounting area not firm.	b. Add support kit or improve construction.
	c. Compressor (could be overloaded due to high ambient or air flow restrictions)	c. Loose internally, no oil. Improper voltage.

Problem	Possible Cause	Repair or Service Needed
Noisy operation (cont'd)	d. Fan motor	d. Blower wheel or blade loose or hitting. Bad bearing.
	e. Defective or wrong capacitor	e. Check for secure mounting, correct part, correct wiring.
	f. Defective relay	f. Check for secure mounting, correct part, correct wiring, correct mounting position.
Evaporator frosts up	a. Low outside air temperature (below 70°).	a. Instruct customer that operation in these ambients is not considered normal requirement of unit.
	b. Thermostat defective or set too cold.	b. Check thermostat and/or instruct customer.
	c. Improper air flow.	c. Dirty filter. Air passages restricted or obstructed. Exhaust door open. Dirty evaporator coil. Dirty blower wheel. Loose blower wheel on shaft
	d. Fan motor too slow.	d. Using low fan speed; instruct customer. Improper reactor top. Low voltage; adjust reactor. Wrong motor or blower wheel. Check for binding of fan blade, blower wheel or motor shaft.
	e. Defective unit	e. Check for restriction or loss of refrigerant.
Moisture dripping into room	a. Extreme humidity	a. Advise customer of possible sweating formations under abnormal conditions. Check and improve all possible seals, minimize door opening.
	b. Inadequate seal	b. Check and improve all sealed areas.
	c. Improper leveling	c. Check for proper side-to-side level of cabinet and unit. Check for ¼" (or ½ to 1 full bubble on level) slope of cabinet toward outside.
	d. Moisture drain holes plugged	d. Check and clean. Advise customer of proper maintenance.

Job Sheet REF-32c

1. The instructor will assign a window air conditioner with an electrical problem. Record the Unit Serial Number below.
2. Using the VOM, tools and previous troubleshooting chart locate the problem.
3. Write down the problem in the space provided.
4. Write down what you think is required to put the unit back in operation.

W/AC Serial Number ____________________

Problems Found ____

____

____

____

____

____

Work Required to Restore Unit to Operation ______________________

____

____

____

____

____

MAJOR BLOCK Refrigeration **NAME** ____

TASK Refrigerators & Freezers

UNIT Understanding Basic Operation **TIME (est.)** ____ **(act.)** ____

UNIT NO REF-33

OBJECTIVE(S)

The student will recognize the basic components of the refrigerator and freezer refrigeration cycle and describe the operation of these parts.

START → W-1 → A-1 → W-2 → C-1 → W-3 → A-2 → W-4 → C-2 → L-1 → C-3

WRITTEN ASSIGNMENT(S)		**AUDIOVISUAL(S)**	
W-1	Information Sheet REF-33a	**A-1**	Slide Set REF-33a
W-2	Assignment Sheet REF-33a	**A-2**	Slide Set REF-33b
W-3	Information Sheet REF-33b	**A-3**	
W-4	Assignment Sheet REF-33b	**A-4**	
W-5		**A-5**	
W-6		**A-6**	
W-7		**A-7**	

LABORATORY ASSIGNMENT(S)		**CHECKPOINT(S)**	
L-1	Job Sheet REF-33a	**C-1**	Instructor Check
L-2		**C-2**	Instructor Check
L-3		**C-3**	Instructor Check
L-4		**C-4**	
L-5		**C-5**	
L-6		**C-6**	
L-7		**C-7**	
L-8		**C-8**	
L-9		**C-9**	

I. Refrigeration components and their function, (refer to Figure A).

1. Compressor - The pump of a refrigerating system that draws a vacuum or low pressure on the cooling portion of the refrigerant cycle and compresses the vaporized refrigerant into the high pressure side of the system.

2. Pre cooler or oil cooler - A small condenser which removes some heat from the hot refrigerant vapor then is returned to the compressor to supply additional cooling by way of a closed loop of tubing through the oil.

3. Discharge Line - The tube coming from the outlet side of the compressor carrying high pressure refrigerant vapor to the condenser.

4. Condenser - The component in the system that receives hot, high pressure refrigerant vapor from the compressor. It disperses the heat to the surrounding air and allows refrigerant to return to a liquid state.

5. Liquid Line - Carries the condensed (liquid) refrigerant from the condenser to the dryer.

6. Filter-Dryer - Provides a means of removing moisture from the refrigerant.

7. Capillary Tube or Metering Device - A means of controlling refrigerant flow usually consisting of a pre-determined length of tubing having a small inside diameter. The longer the tube or smaller the diameter the less refrigerant will flow. The shorter the tube or larger the diameter the more refrigerant will flow. This is necessary in order for the compressor to maintain a high and low pressure in the system.

8. Evaporator - The part of a refrigerating mechanism in which the refrigerant vaporizes and absorbs heat.

9. Suction Line - The tubing that carries the lower pressure vapor from the evaporator back to the compressor.

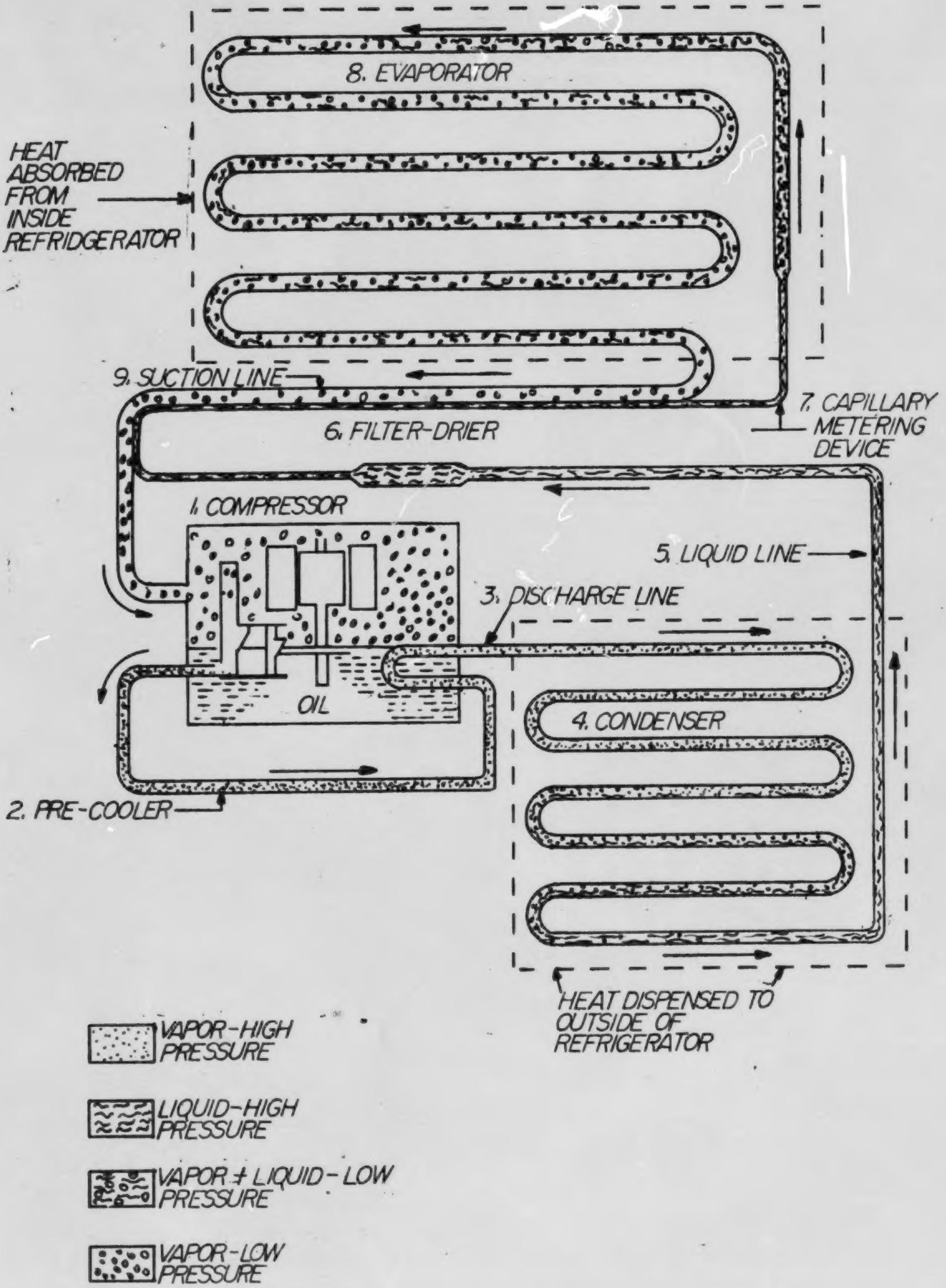

8. EVAPORATOR
HEAT ABSORBED FROM INSIDE REFRIDGERATOR
9. SUCTION LINE
7. CAPILLARY METERING DEVICE
6. FILTER-DRIER
1. COMPRESSOR
5. LIQUID LINE
3. DISCHARGE LINE
OIL
4. CONDENSER
2. PRE-COOLER
HEAT DISPENSED TO OUTSIDE OF REFRIGERATOR
VAPOR-HIGH PRESSURE
LIQUID-HIGH PRESSURE
VAPOR + LIQUID-LOW PRESSURE
VAPOR-LOW PRESSURE
OIL

FIGURE A

Assignment Sheet REF-33a

1. Using the space provided draw a refrigeration system showing the four major components and piping, color the drawing to the color scheme provided below.
2. Explain briefly what takes place in each component.
3. You may refer back to the previous information sheet and illustration.
4. Do your work as accurately and neatly as possible.

Red —Vapor high pressure

Blue —Vapor low pressure

Green —Liquid high pressure

Yellow —Vapor and liquid low pressure

Type and Location of the Refrigerator/Freezer Components

The compressor used in the modern refrigerator or freezer will be of the sealed type and either reciprocal (Figure B) or rotary (Figure C) design.

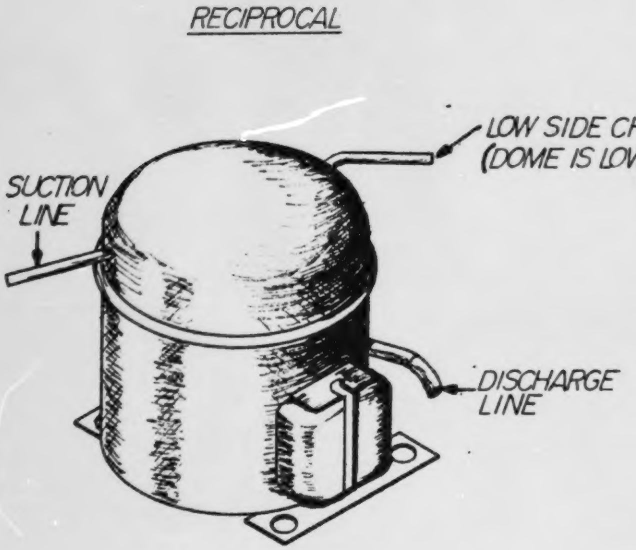


FIGURE B

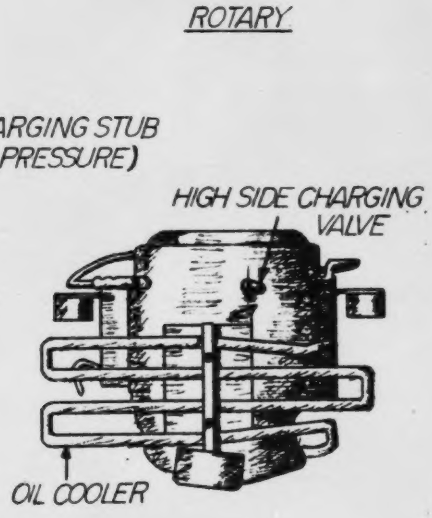


FIGURE C

The compressor will be mounted at the bottom underneath the refrigerator/freezer and underneath and on one end of the chest type freezer.

The condenser will be either forced air or static design and may be either plate, fin, or tube type (Figure D). As can be seen in the illustration the forced air condenser is mounted underneath the refrigerator/freezer next to the compressor. The condenser fan blows air across the unit to help remove the heat. Dust accumulation on the condenser must be removed periodically to allow maximum cooling.

The static condenser does not have a fan to force air over it and therefore requires more room to allow the heat to dissipate. The static condenser is usually mounted in the wall of the refrigerator/freezer or on the back (Figure E). The high pressure vapor discharge line connects the compressor to the condenser.

The liquid line, attached to the outlet side of the condenser on one end, will have the filter dryer and metering device (capillary tube) attached to it on the other end. Both the dryer and capillary tube are usually located underneath the refrigerator/freezer. Often the capillary tube is coiled to prevent breakage due to vibration. When replacing the tube the size and length must be the same as the original.

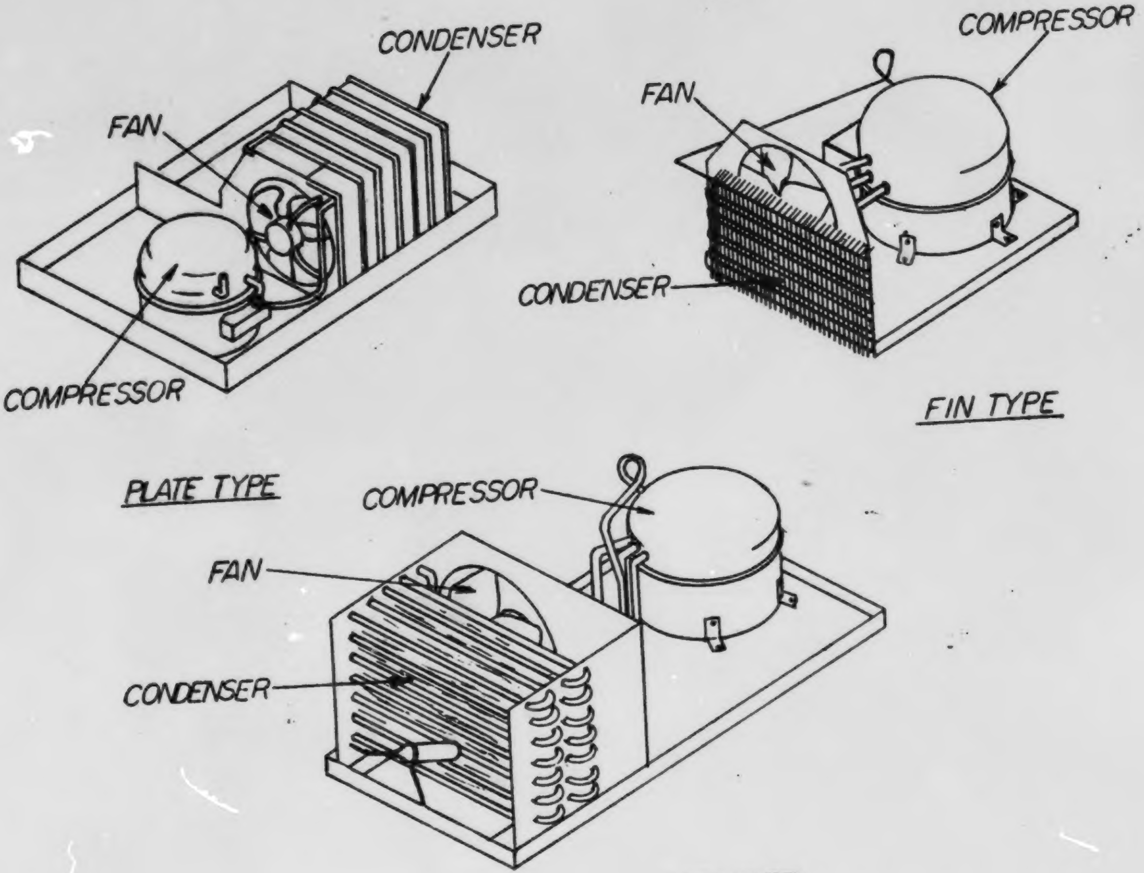


PLATE TYPE

FIN TYPE

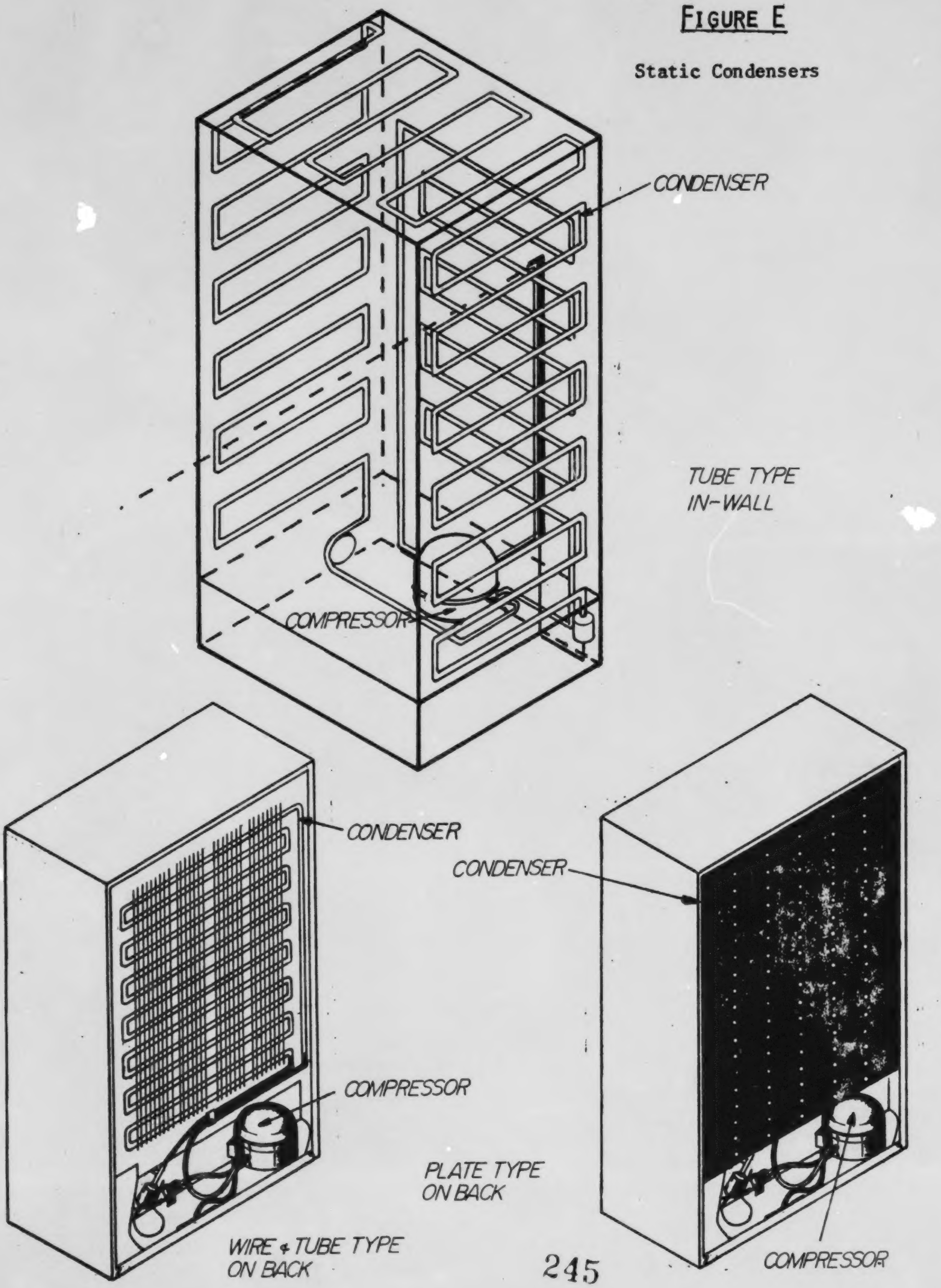
TUBE TYPE

FIGURE D

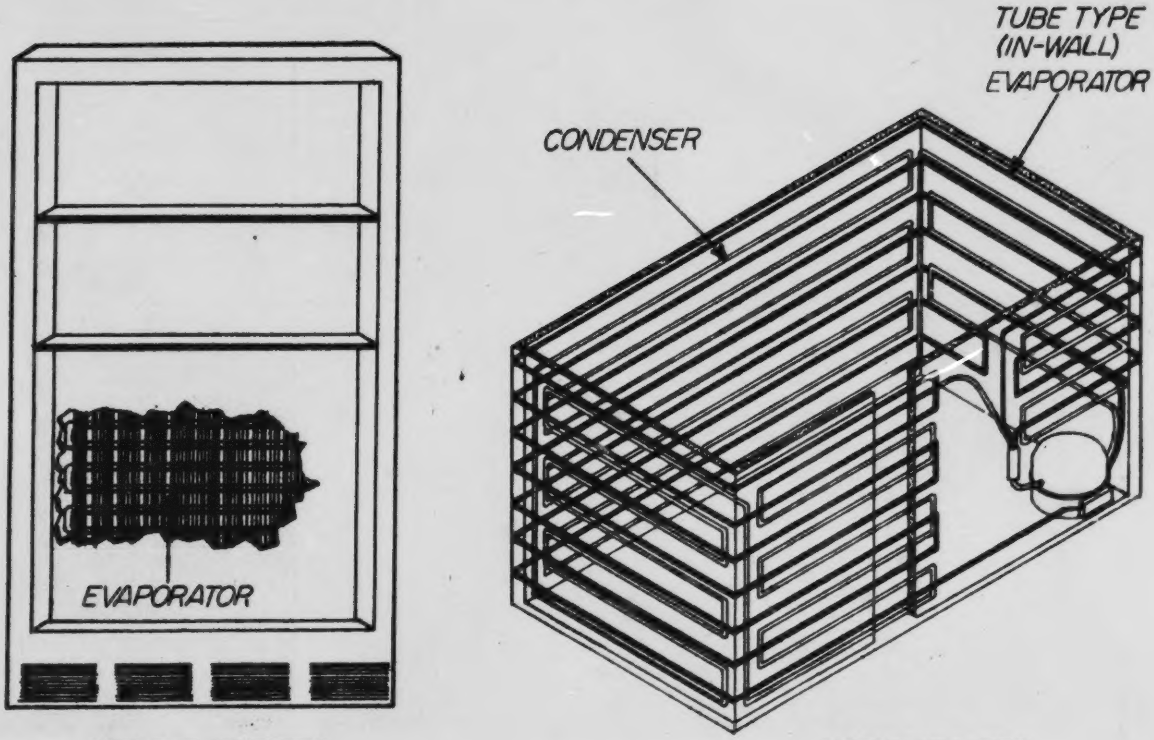
Types of Forced Air Condensers

FIGURE E

Static Condensers



The capillary tube leads directly to the evaporator. The evaporator is generally located in the freezer compartment of the refrigerator/freezer or it may be used as a shelf in a freezer or located in the back wall of a chest or upright freezer (Figure F and Figure G).



UPRIGHT FREEZER

CHEST FREEZER

FIGURE F

TYPES OF FREEZERS

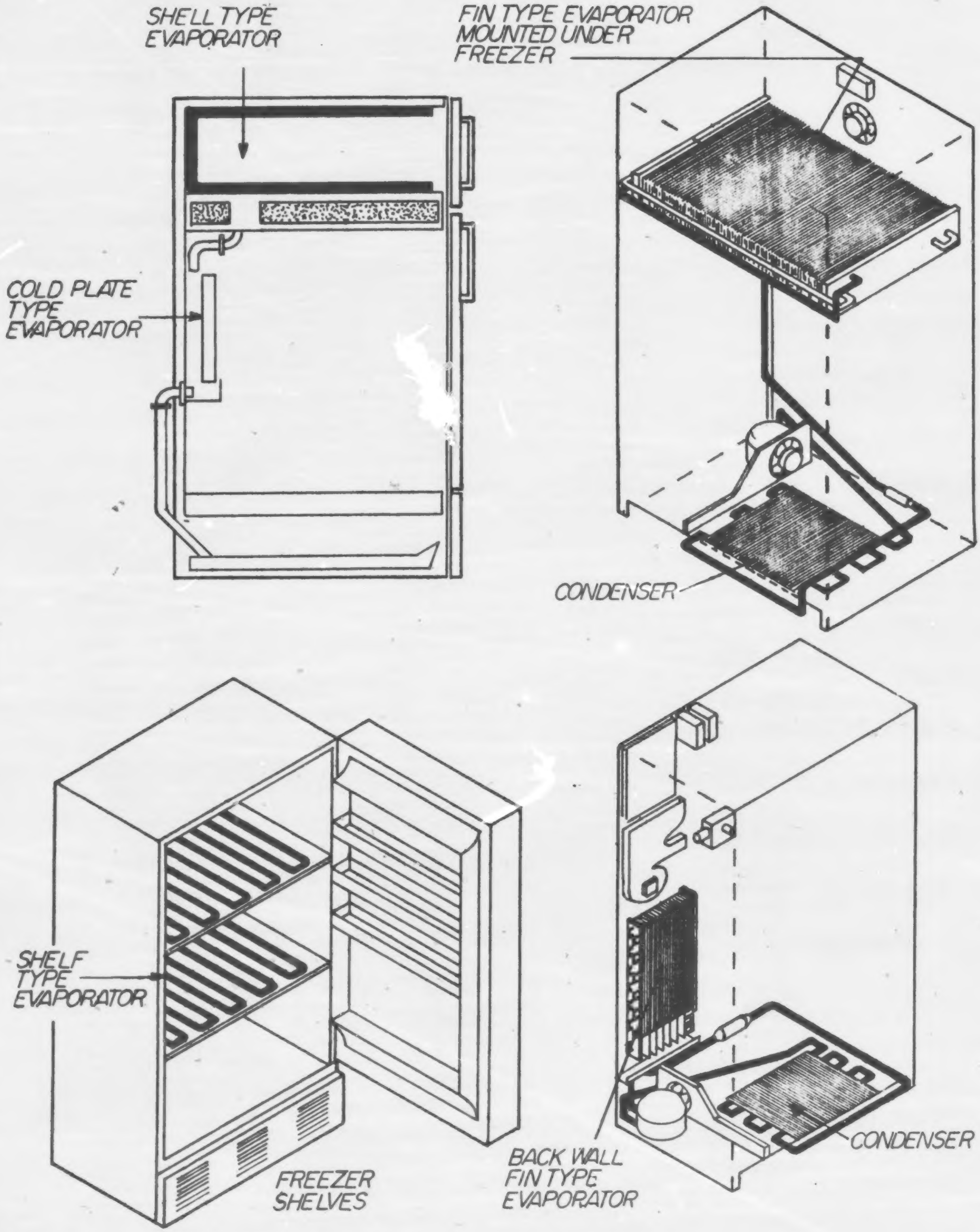

SHELL TYPE EVAPORATOR
FIN TYPE EVAPORATOR MOUNTED UNDER FREEZER
COLD PLATE TYPE EVAPORATOR
CONDENSER
SHELF TYPE EVAPORATOR
FREEZER SHELVES
BACK WALL FIN TYPE EVAPORATOR
CONDENSER

FIGURE G

Types and Locations of Evaporators

1. From the list of part names listed below, locate and label these parts on operational refrigerators and freezers in the lab.
    a. Reciprocating compressor (piston type)
    b. Rotary compressor
    c. Capillary tube
    d. Filter dryer
    e. Shell evaporator
    f. Shelf evaporator
    g. Plate evaporator
    h. Fin condenser
    i. Plate condenser
    j. Tube (in wall) condenser
    k. Heat exchanger
2. Check with the instructor when you have finished.

Job Sheet REF-33a

In order to get a better idea of how the refrigerator controls work, do the following job.

1. Check out from the supply room a box containing the following items. Temperature control, hot wire relay, overload, and defrost timer.
2. Check out tools as necessary to disassemble components and examine. CAUTION: Do not take the temperature control apart as the bellows exerts pressure and would be very difficult to reassemble. Remove only the excess cover at one end that slips out of its retainer.
3. Explain briefly in the space provided, how each item operates. View slide set REF-33b again if necessary.

Temperature Control	Hot Wire Relay
____________________	____________________
____________________	____________________
____________________	____________________

Overload	Defrost Timer
____________________	____________________
____________________	____________________
____________________	____________________

MAJOR BLOCK Refrigeration **NAME** ____________

TASK Refrigerators and Freezers

UNIT Evacuating and Charging Refrigerators and Freezers **TIME (est.)** ________ **(act.)** ________

UNIT NO REF-34

OBJECTIVE(S)

Evacuate and charge domestic refrigerator and freezer systems.

START → W-1 → A-1 → L-1 → C-1 → W-2 → L-2 → C-2
W-3 → L-3 → C-3 → W-4 → L-4 → C-4 → W-5 → L-5 → C-5
L-6 → C-6 → W-6 → L-7 → C-7

WRITTEN ASSIGNMENT(S)		**AUDIOVISUAL(S)**	
W-1	Information Sheet REF-34a	**A-1**	Slide Set REF-34a
W-2	Text Assignment REF-34a	**A-2**	
W-3	Text Assignment REF-34b	**A-3**	
W-4	Text Assignment REF-34c	**A-4**	
W-5	Text Assignment REF-34d	**A-5**	
W-6	Information Sheet REF-34b	**A-6**	
W-7		**A-7**	

LABORATORY ASSIGNMENT(S)		**CHECKPOINT(S)**	
L-1	Job Sheet REF-34a	**C-1**	Instructor Check
L-2	Job Sheet REF-34b	**C-2**	Instructor Check
L-3	Job Sheet REF-34c	**C-3**	Instructor Check
L-4	Job Sheet REF-34d	**C-4**	Instructor Check
L-5	Job Sheet REF-34e	**C-5**	Instructor Check
L-6	Job Sheet REF-34f	**C-6**	Instructor Check
L-7	Job Sheet REF-34g	**C-7**	Instructor Check
L-8		**C-8**	
L-9		**C-9**	

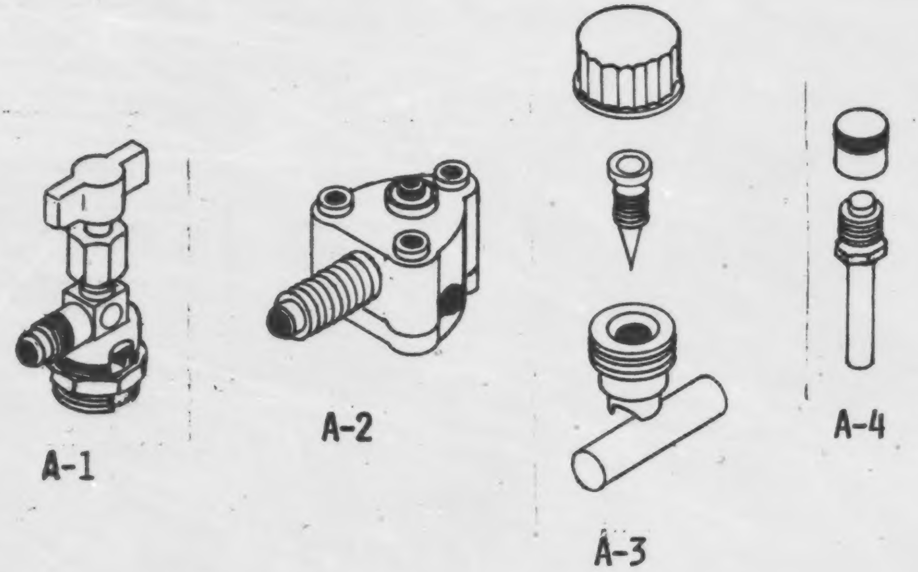
Access valves are used to gain entrance to a sealed refrigeration system without losing the refrigerant. Such valves are considered as temporary; in fact, some manufacturers will void the warranty if the valve is left on the system. Domestic refrigerators and freezers use four general types of access valves as shown in Figure A and described below.

(A-1) Line piercing type with hand valve that clamps on tubing and pierces the tubing by turning valve in. Access is gained by turning the valve out.

(A-2) Line piercing type with allen head valve (bullet type) that clamps on tubing. Tubing is pierced by turning allen head valve in. Access is gained by turning valve out (no more than two turns).

(A-3) Line piercing type with a separate hand valve that clamps on tubing and pierces by turning the center screw in. Operated by attaching hand valve and manipulating center screw.

(A-4) Schrader or access core type. This valve is soldered into the system usually to the access tube on the compressor. The valve core is operated by a core depressor in the refrigerant hose.



Access Valves - Domestic Refrigeration

FIGURE A

Install a line piercing, clamp-on valve using the following procedure.

1. Check out from the tool room marking tags and a clamp-on access valve.
2. Using a refrigerator assigned by the instructor, label all lines connected to the compressor.
3. Label the compressor as reciprocating or rotary.
4. Label the process tube as high side or low side.
5. Install clamp-on access valve in the appropriate place.

NOTE: Using a compressor start cord would be out of place in this job. This will be done at a later time.

Triple Evacuation

1. Check out the following items from the tool room: vacuum pump, manifold gauge, refrigerant #12, and safety glasses.

2. Check out any tools and fittings necessary to connect the manifold to the refrigerator assigned by the instructor.

3. Connect manifold gauges as follows:

   (a) Low side hose to refrigeration system
   (b) High side hose to F-12
   (c) Center hose to vacuum pump

4. Close all valves and evacuate as follows:

   (a) Open low side valve and compressor shut-off valve
   (b) Start vacuum pump and pull down to 28" on gauge and then pump for 15 minutes.
   (c) Close pump valve and turn off pump
   (d) Open refrigerant valve and bring system pressure up to approximately 2 psig. Close refrigerant valve. (NOTE: If gauge does not read at least 2 psig after valve has been shut off, add more refrigerant and let set for five minutes.)
   (e) Open pump valve and again pull down to 28" psig and then pump for 15 minutes.
   (f) Close pump valve and turn off pump
   (g) Repeat step (d)
   (h) Repeat step (e)
   (i) Close pump valve and turn off pump
   (j) System is now ready for refrigerant charge

NOTE: If system is not to be charged at this time, add a holding charge of approximately 5 psig to the system.

Job Sheet REF-34c

Deep Vacuum Evacuation

1. Check out the following items from the tool room: vacuum pump, high vacuum gauge, manifold gauge, refrigerant #12, and safety glasses.

2. Check out any tools and fittings necessary to connect manifold to the refrigerator assigned by the instructor.

3. Connect manifold gauges as follows:

   (a) Low side hose to refrigeration system
   (b) Using short hoses and one 1/4" flare tee, connect center hose, F-12 and vacuum pump together.
   (c) Close all valves and connect high vacuum gauge. If necessary, contact instructor for assistance.

4. Evacuate as follows:

   (a) Open low side valve and pump valve, start pump.
   (b) Calibrate high vacuum gauge and evacuate to at least 500 microns.
   (c) Close pump valve and shut off pump. Wait 15 minutes and see if system is holding vacuum. If system fails to hold vacuum, check all fittings for tight fit and repeat step (b).
   (d) Close pump valve and shut off pump. Wait 15 minutes and see if system is holding vacuum. If system fails to hold vacuum, there may be a leak or moisture in the system. If this is the case, contact the instructor.
   (e) If system stays below 500 microns, system is ready to be charged. If system is not to be charged at this time, add a holding charge of refrigerant #12.
   (f) Put away all items and clean work area.

Leak Detection

1. Check out the following items from the tool room: manifold gauge, soap bubble, halide torch, electronic leak detector, striker and safety glasses.

2. Using a refrigerator with a known leak, assigned by the instructor, connect the low side hose to system and center hose to refrigerant 12 cylinder and close all valves.

3. Open refrigerant valve (vapor), then open low side manifold valve slowly until system has same pressure as refrigerant cylinder.

4. Check for leaks as follows:

   (a) Soap bubble method - apply to all joints and fittings. When leak is found, wipe solution from all joints and fittings to prevent damage to the other detectors you will be using.
   NOTE: Leak may be too small for soap bubbles to indicate. In any event, wipe joints clean and go to next step.

   (b) Halide Detector - first light and adjust flame as follows. Open valve 1/2 turn, hold striker over torch, create a spark to ignite the gas. Adjust flame so that tip of the blue cone just touches copper element. When copper element becomes red, move sniffer tube opening slowly around all joints and fittings. The flame above the copper element will change color if refrigerant is picked up by sniffer. A small leak will show up in the flame as a light green tint. A large leak will change the flame color to a purple hue. When all fittings have been checked, turn off the Halide Torch and allow to cool before storing.

   (c) Electronic Detector - first adjust according to the instructions on detector (check with the instructor to be sure this is done correctly). Move sensing tip slowly around all joints and fittings until leak is indicated.
   NOTE: (1) If leak is very small, cup hand around joint or fitting to prevent refrigerant from dissipating too quickly. Put sensor tip between hand and joint on fitting.
   (2) Also, if leak is hard to find, the sensitivity adjustment on the detector can be increased. (Check with instructor.)

5. Bleed all refrigerant from refrigerator slowly. Clean work area and return all items to tool room.

6. Show the instructor where the leak is.

Charging with Liquid

1. Check out the following items from the tool room: charging station, refrigerant #12 and safety glasses.

2. Using a refrigerator assigned by the instructor, evacuate the system using the deep vacuum micron method as explained in Job Sheet REF-34c.

3. While the system is evacuating, add a refrigerant charge to the charging cylinder as follows.

   (a) Determine the charge from refrigerator information tag.
   (b) Connect refrigerant #12 cylinder to bottom of charging cylinder with extra hose.
   (c) Open liquid valve on refrigerant cylinder (if this is a small tank, it may need to be inverted in order to get liquid).
   (d) Loosen the hose at the charging cylinder to purge air and refrigerant vapor from hose. When a spot of refrigerant is seen, tighten hose.
   (e) Open the valve at the bottom of charging cylinder and allow refrigerant to enter. When amount of charge (determined in step (a) plus two ozs.) has entered, close valve on bottom of charging cylinder.
   (f) If refrigerant stops entering cylinder before desired level is reached, release vapor from top of cylinder in short bursts. If released too fast, refrigerant in cylinder will boil and the level will not be read correctly. If refrigerant boils (bubbles rising), wait for boiling to stop, then continue.

4. When the charge plus two ounces has been added, turn off both valves. Loosen hose at one end and allow refrigerant to bleed out slowly.
   CAUTION: Liquid refrigerant dripping from the hose can cause severe frost bite or burns. Do not allow it to contact skin.

5. When evacuation is complete, turn low side valve off first, then turn off pump. Remove center hose from pump and connect to bottom of charging cylinder. Open valve on bottom of charging cylinder. Loosen center hose at manifold and purge air and vapor out. Tighten hose.

6. Read amount of refrigerant now in charging cylinder and subtract amount of refrigerant charge to be put into refrigerator. This will give the amount to be left in cylinder when charging is complete.

7. Open low side valve and add a charge to the system. The last few ounces should be added slowly to prevent over-shooting correct charge. Close valve when correct charge is reached.

8. Close charging cylinder valve and bleed refrigerant from center hose.

9. System is ready to be sealed. If not to be sealed at this time, bleed refrigerant from system, return tools and equipment and clean work area.

Charging with Vapor

1. Check out the following items from the tool room: Charging station, refrigerant #12 and safety glasses.

2. Using a conventional refrigerator (non-defrosting and without rotary compressor) assigned by the instructor, evacuate the system.

3. When properly evacuated, charge the system as follows:

    (a) Close low side valve and turn off pump
    (b) Remove center hose from pump and connect to refrigerant cylinder
    (c) Open cylinder valve for vapor and purge air out of hose at manifold
    (d) Start refrigerator. Open low side valve and allow vapor to enter system slowly. Add refrigerant until ten pounds pressure is indicated in system when low side valve is closed.
    (e) Run refrigerator for at least one hour and adjust pressure in system to 3 psig, by either adding refrigerant or bleeding refrigerant out of system. Operate for 30 minutes and balance again, if necessary.

4. Evaporator should have a full frost pattern and the suction line at the compressor should not be cold.

5. Turn off refrigerator and bleed refrigerant from system slowly. Put cap on refrigerator connections to prevent air from entering the system. Return all tools and equipment and clean work area.
    NOTE: Refrigerators with rotary compressors can be charged this way but the process is much slower. The compressor must run for one hour before system operation will settle down and pressure will raise out of a vacuum.

Sealing the System

A hermetically sealed system is one in which all joints and connections are sealed with silver solder and the compressor and motor are sealed inside a housing. When access has been gained, it is necessary to reseal the system. This is done by closing and sealing the process tube after the refrigerator has been serviced, thereby, returning the system to a hermetically sealed condition again. A pinch-off tool (as shown in Figure B) is used to pinch the process tube and allow the end of the process tube to be sealed with solder without losing refrigerant from the system.

Three Types of Pinch-Off Tools

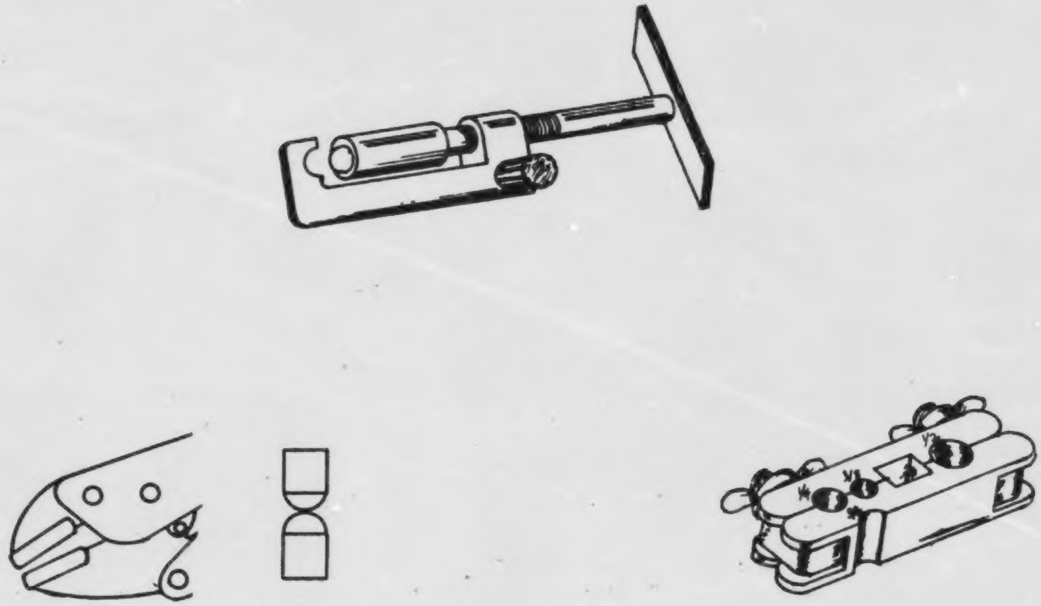


FIGURE B

Seal the System

1. Check out the following items from the tool room: Manifold gauge, pinch-off tool, tubing cutter, diagonal cutter, striker, silver solder, flux, refrigerant #12, acetylene torch and safety glasses.

2. Using the refrigerator assigned by the instructor, pressurize system to 30 psi. (System should have a process tube at least eight inches long; if not, this must be installed first.)

3. Place pinch-off tool on tubing approximately four inches from the compressor as in Figure C. (This allows room to attach an access valve to test the system at a later date, if necessary.) The tool is left on the tubing during soldering.

4. Cut tubing off between pinch-off and service hose connection or access valve (placed at least two inches from pinch-off to prevent pinch-off tool from operating as a heat sink, making it difficult to solder tubing). See Figure D.

5. Using a diagonal cutter, pinch tubing together 1/4 inch from end.

6. Fill inside of tubing with solder to seal system. (If pinch-off tool is not tight enough, a bubble will appear in solder; if this happens, tighten pinch-off tool and resolder.) By sealing the tubing in this manner, a check for a good joint can be done visually. See Figure E.

7. Remove pinch-off tool, return tools and equipment and clean work area.

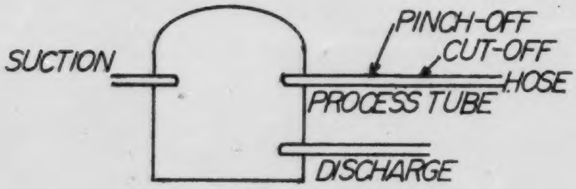


FIGURE C

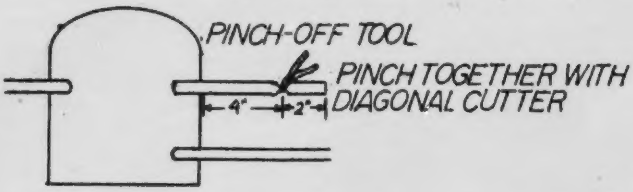


FIGURE D

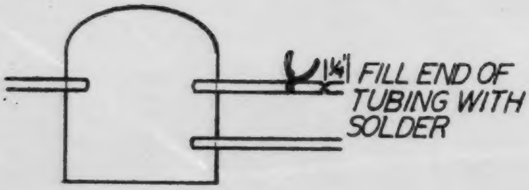


FIGURE E

MAJOR BLOCK Refrigeration **NAME** ______

TASK Troubleshooting Refrigeration Cycle

UNIT Refrigerators and Freezers **TIME (est.)** ______ **(act.)** ______

UNIT NO REF-35

OBJECTIVE(S)

Troubleshoot the refrigeration cycle in a refrigerator or freezer.

START → W-1 W-2 L-1 C-1 A-1 W-3 L-2 C-2

WRITTEN ASSIGNMENT(S)		**AUDIOVISUAL(S)**	
W-1	Text Assignment REF-35a	**A-1**	Slide Set REF-35a
W-2	Information Sheet REF-35a	**A-2**	
W-3	Information Sheet REF-35b	**A-3**	
W-4		**A-4**	
W-5		**A-5**	
W-6		**A-6**	
W-7		**A-7**	
LABORATORY ASSIGNMENT(S)		**CHECKPOINT(S)**	
L-1	Job Sheet REF-35a	**C-1**	Instructor Check REF-35a
L-2	Job Sheet REF-35b	**C-2**	Instructor Check REF-35b
L-3		**C-3**	
L-4		**C-4**	
L-5		**C-5**	
L-6		**C-6**	
L-7		**C-7**	
L-8		**C-8**	
L-9		**C-9**	

Refrigerator Pressures

1. High Side Pressure

    a. In domestic refrigerators and freezers, the high side pressures are usually not considered in diagnosing.
    b. Consideration would be given if the refrigerator had been in operation long enough to pull down to normal operating temperatures and the condenser was still quite hot.

    Possible causes to look for:

    1. Light staying on (bad light switch)
    2. Air leaks (door gasket, drain tubes, etc.)
    3. Heater staying on (evap. heater, drain heater, etc.)
    4. Excessive cool down time caused by a large amount of unfrozen food put in the freezer.

2. Low Side Pressure (Refrigerator has run long enough that normal temperatures should have been obtained and any problems from above, if existing, have been eliminated.)

    a. Non-self defrosting refrigerator or freezer approximately 3 psi
    b. Self defrosting refrigerator or freezer approximately 3 psi to 3 in. vac.
    NOTE: These pressures can vary slightly due to varying room temperature.

Check Refrigerator for Proper Operation

1. Using refrigerator assigned by instructor, check for proper operation. Refrigerator should have run for at least 2 hours.
2. Check out from tool room safety glasses and any tools or equipment needed to complete this job sheet.
3. Check for air leaks, correct any found, and record what was found and how it was corrected.

4. Check and record temperature. Allow time for temperature to settle down after opening doors to insert temperature tester.

   a. freezer temperature __________
   b. fresh food temperature __________

   If temperature recorded is not correct, adjust thermostat for proper temperature.
5. Using techniques discussed in previous section, check low side pressure and record.

   ______________ psi

6. Return all tools and equipment and clean work area.

A. Possible problem: Non-self defrost refrigerator.

   1. Pressure too high (low side)
      a. Overcharge
      b. Low capacity compressor (not pumping enough)
      c. Excessive heat load
   2. Pressure too low
      a. Low charge
      b. Restriction (tubing partially or totally blocked)

B. Possible Problem - Self defrost refrigerator.

   1. Pressure too high
      a. Overcharge
      b. Low capacity compressor (not pumping enough)
      c. Excessive heat load.
   2. Pressure too low
      a. Low charge
      b. Restriction (tubing partially or totally blocked)
      c. Evaporator fan motor running slow or not at all
      d. Defrost system not operating properly allowing heavy frosting buildup blocking air flow.
      e. Freezer not closed all the way allowing moist air to be drawn in and across evaporator, causing frost buildup too heavy for defrost system to remove. (Usually, this happens at night.)

Troubleshooting Chart

Symptom	Possible Cause	Steps to Diagnosis	Repair
Short frost pattern	leak	1. check pressure 2. add refrigerant 3. leak check	repair leak and recharge
	restriction	1. check pressure 2. add refrigerant 3. check for cool spot in dryer and capillary tube.	1. correct restrictions 2. If unable to pin point restrictions, replace dryer. 3. If still restricted, pressure check individual components. a. capillary tube b. condenser c. evaporator d. suction line
	low capacity compressor	1. check pressure 2. add refrigerant a. pressure goes up-bad compressor b. pressure goes down-leak	replace compressor
very short frost pattern	leak	see above	see above
	low capacity compression	see above	see above
	restriction (moisture)	1. check pressure 2. add refrigerant 3. apply heat	1. replace dryer 2. evacuate while applying heat to evaporator 3. recharge
not cold enough or excessive running time with frost or moisture on suction line at compressor.	overcharge	check pressure	bleed back to correct pressure while watching frost pattern or evacuate and recharge.
	capillary tube separated from suction line.	visually inspect heat exchanger	Wrap entire length of heater exchange with copper wire to hold capillary tube against suction line.
frost buildup on plate covering evaporator (frost free)	hot gas bypass valve	Apply power directly to bypass valve coil and check coil for magnetic field (insert metal such as screwdriver in center of coil).	1. magnetic field present but valve will not operate a. replace valve. 2. no magnetic field present a. replace coil 3. magnetic field present and valve does operate. a. diagnose defrost electrical system.

Diagnose and Repair Refrigerator

1. Using refrigerator assigned by instructor, diagnose and repair.
2. Refer back to any material that will assist you to diagnose and repair.
    a. Symptoms:

    b. List steps taken to diagnose:
        1.
        2.
        3.
        4.
        5.
        6.
        7.
        8.
        9.
        10.

    c. Diagnose the problem based on steps listed above.

    d. How was the problem repaired?

MAJOR BLOCK Refrigeration **NAME** ____________

TASK Refrigerator and Freezer

UNIT Troubleshooting Fans and Fan Motors **TIME (est.)** ______ **(act.)** ______

UNIT NO REF-36

OBJECTIVE(S) Test and repair fans, fan motors, switches, and connections.

START → A-1 → W-1 → W-2 → L-1 → C-1 → L-2 → C-2

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-36a
W-2 Information Sheet REF-36b
W-3 ____________
W-4 ____________
W-5 ____________
W-6 ____________
W-7 ____________

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-36a
L-2 Job Sheet REF-36b
L-3 ____________
L-4 ____________
L-5 ____________
L-6 ____________
L-7 ____________
L-8 ____________
L-9 ____________

AUDIOVISUAL(S)

A-1 Slide Set REF-36a
A-2 ____________
A-3 ____________
A-4 ____________
A-5 ____________
A-6 ____________
A-7 ____________

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 ____________
C-4 ____________
C-5 ____________
C-6 ____________
C-7 ____________
C-8 ____________
C-9 ____________

Mechanical Problems with Fan Motors and Fan Blades

Evaporator Fan Motor - used to circulate air across cold evaporator and through refrigerator.

Condenser Fan Motor - removes heat from condenser by blowing or drawing air across condenser.

Problems	Evaporator Fan	Condenser Fan
No air flow	1. No power to motor and turns freely 2. Ice or frost build-up against fan blade 3. Loose item in fan area blocking blade 4. Bearing stuck, dry of oil 5. Fan blade bent and wedged	1. No power to motor and motor turns freely 2. Excessive lint build-up 3. Paper or plastic caught around fan blade (fan turns) 4. Loose item in fan area blocking: paper, plastic, mouse, etc. 5. Bearing stuck, dry of oil 6. Fan blade bent and wedged
Restricted air flow	1. Low voltage to motor (bad connection in wiring or switch) 2. Ice or frost build-up on evaporator (fan turns) 3. Bearing dry and fan turns slowly 4. Loose item in fan area blocking air flow (fan turns) 5. Fan blades bent out of shape (fan turns)	1. Low voltage to motor (bad connection in wiring or switch) 2. Lint build-up on condenser and fan blade. 3. Bearing dry and fan turns slow 4. Loose item in fan area blocking air flow (fan turns) 5. Fan blade bent out of shape (fan turns)

Fault	Repair
No voltage or lower voltage	See electrical check list
Ice or defrost build-up	1. Defrost problem 2. Customer spills water from ice trays
Dry bearing	Condenser 1. Fill oil switch with oil 2. If bearing worn allowing side play in shaft do not use motor - replace Evaporator 1. Replace motor
Loose item in fan area	Remove item
Fan blade bent	Straighten blades and reset blade angle
Lint build-up	Remove lint from coils and fan blade
Fan noisy	1. Bearing bad (see dry bearing) 2. Blade bent (see fan blade bent) 3. Rubber mounts bad (replace)

Fan Motor Electrical Check Using Attached Wiring Diagram

General:

Problems in the electrical system can sometimes be found by doing a simple visual inspection. Look for loose connection (moving connector sometimes helps), broken wire, corrosion around connections, etc.

Diagnose with power off: (Does not need to be done in this order)

1. Disconnect fan switch and check with ohmmeter, switch button must be depressed. (Checkpoint 1 and 2 in diagram)
2. Disconnect fan motor and check with ohmmeter (checkpoint 3 in diagram)
3. Check across plug in connector (checkpoint 4 in diagram)

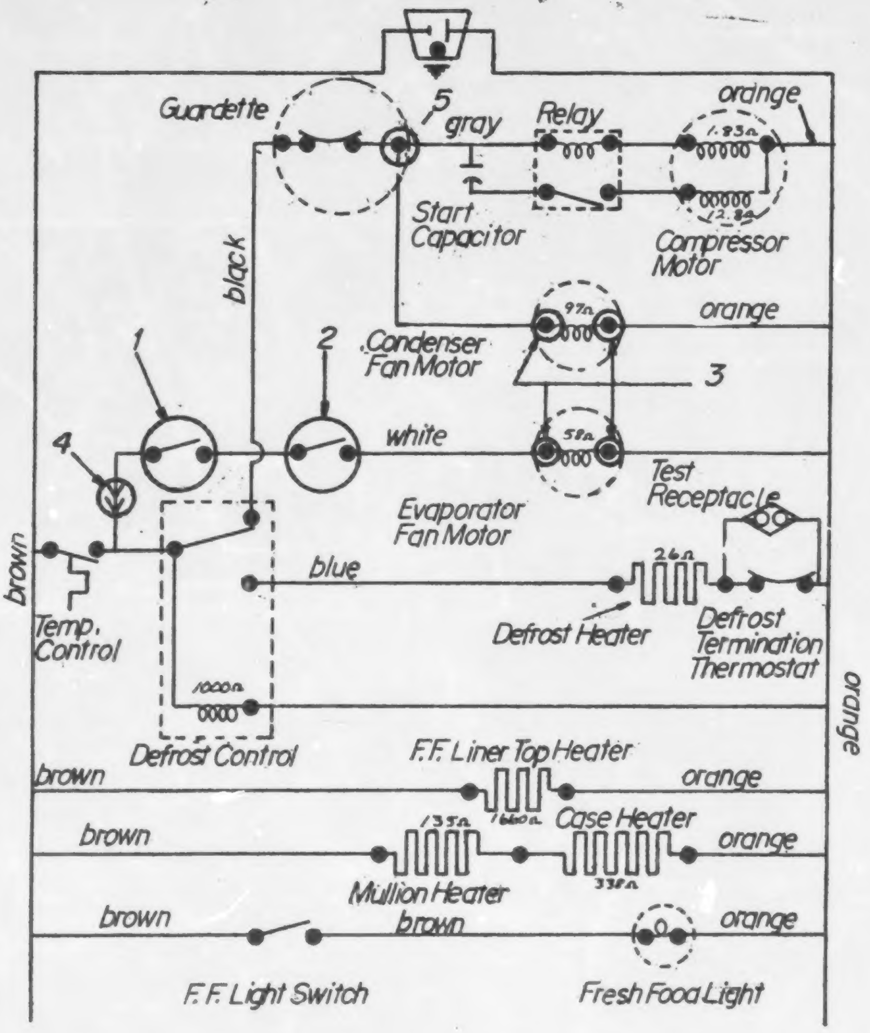
NOTE: Checkpoints 1, 2, and 4 should show no resistance. Checkpoint 2 (fan motor) should show resistance.

Diagnose with power on: Use Caution (Does not need to be done in this order)

1. Test across fan switch, checkpoints 1 and 2
   a. switch button out should show voltage
   b. switch button depressed should show no voltage
2. Test across fan motor, checkpoint 3
   a. voltage indicated but fan won't run, bad fan motor
   b. no voltage indicated, look for trouble elsewhere
3. Test across connectors, checkpoint 4
   a. voltage indicated, bad connector
   b. no voltage indicated, good connections

NOTES:

1. If no connections at motor to use in testing, pins can be inserted into the wire to make test points - Caution: do not insert pins with power on.
2. Pins can be used at other points for testing - same caution
3. Remove pins after testing.



ELECTRICAL CHECKPOINTS

1. Fan switch in fresh food compartment (if used)
2. Fan switch in freezer compartment
3. Plug in connections at fan motor
4. Plug in connections in wiring harness (if used)
5. Connections at compressor guardette

Electrical Test

1. Check out a multimeter plus any other equipment needed
2. Using equipment assigned by instructor check for the following and list findings on back of this page.
    a. Fan motor bearings
        1. tight
        2. too loose
        3. end play
        4. side play
    b. Fan motor windings
        1. shows resistance (indicates good)
        2. no resistance (open winding)
    c. Switches
        1. good
        2. bad
    d. bad connection
3. Return all tools and equipment and clean work area

Replace Fan Motor

1. Check out necessary tools.
2. Using refrigerator assigned by instructor:
    a. replace evaporator fan motor and blade
    b. replace condenser fan motor and blade
3. Both fan motors should operate with no vibrations after being replaced.
4. Return all tools and clean work area.

MAJOR BLOCK Refrigeration **NAME**

TASK Refrigerator and Freezer

UNIT Troubleshooting compressor burnout on refrigerators and freezers **TIME (est.)** **(act.)**

UNIT NO REF-37

OBJECTIVE(S) Troubleshoot a compressor burnout on a refrigerator or freezer

START → W-1 A-1 W-2 W-3 C-1 L-1 C-2 L-2 W-4 L-3 C-3

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-37a
W-2 Information Sheet REF-37b
W-3 Assignment Sheet REF-37a
W-4 Information Sheet REF-37c
W-5
W-6
W-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-37a
L-2 Job Sheet REF-37b
L-3 Job Sheet REF-37c
L-4
L-5
L-6
L-7
L-8
L-9

AUDIOVISUAL(S)

A-1 Slide Set REF-37a
A-2
A-3
A-4
A-5
A-6
A-7

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 Instructor Check
C-5
C-6
C-7
C-8
C-9

Causes of Compressor Burnout

Cause	- Result of:
Excessive heat load over long period	1. Door gaskets not sealing properly 2. Refrigerator next to stove if oven is used frequently 3. Light staying on when door is closed
Compressor running too hot	1. See above 2. Inadequate air circulation around condenser (natural draft) 3. Lint buildup on condenser 4. Condenser fan motor not running 5. Condenser fan motor running slow 6. Air flow across condenser obstructed by foreign matter, plastic, paper, etc. 7. System short of refrigerant 8. Low capacity compressor 9. System restriction
Compressor tries to start but will not run	1. Bad relay 2. Bad start winding (open, shorted) 3. Bad connections (relay or start winding) 4. Compressor stuck mechanically 5. Low voltage
Compressor starts up then shuts off (short cycle)	1. Bad overload 2. Bad connection (relay or run winding) 3. Bad run winding (open, shorted, or partial short causing high resistance) 4. High voltage
Cause not related to refrigerator	Result:
Low voltage	1. Compressor runs hot (see above) 2. Compressor tries to start (see above)
Lightning and/or high voltage	Voltage too high for compressor and burn winding

Compressor Check for Burnout, Short, Open or Ground

1. Burnout
   A. Compressor will not run
   B. High resistance on winding or open winding
   C. Burned odor may be present

   NOTE: The type oil used in some compressors will have a burned odor even if the compressor is alright. This should not be the only factor used to condemn a compressor.

2. Short
   A. Winding has low resistance or
   B. Winding has no resistance

3. Open
   Winding has total resistance (infinity)

4. Ground
   Resistance indicated between winding and compressor case

Determine Start, Run and Common Windings on compressor

Heremetic compressors have three terminals that are connected to the internal motor windings. By taking three resistance readings across these terminals it can be determined which terminals are start, run, and common.

1. Find the highest reading across two terminals. These will be start and run (the other terminal will be common)

2. Find the next highest reading across two terminals. Since common has been determined, the other terminal will be start.

3. Find the lowest reading between two terminals. Since common has been determined, the other terminal will be run.

Example:

Terminal B is Common

Terminal C is start

Terminal A is run

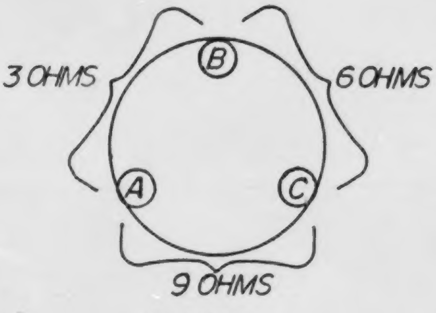
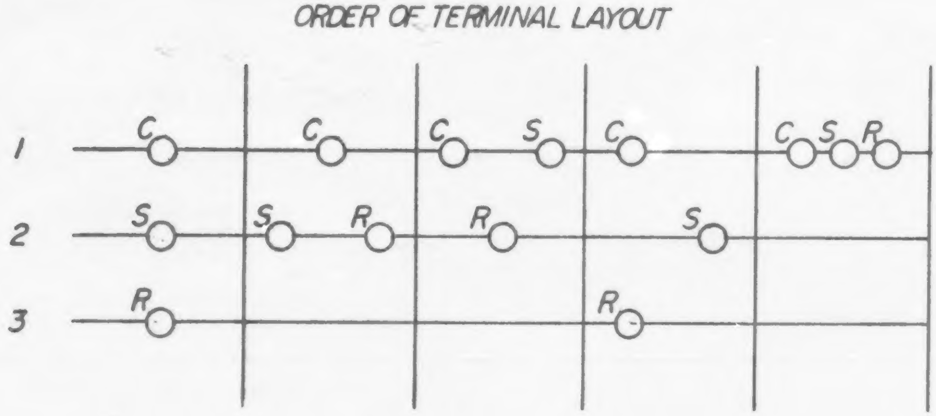


FIGURE A

On Tecumseh built compressor only the following chart can be used (this chart is easily memorized):



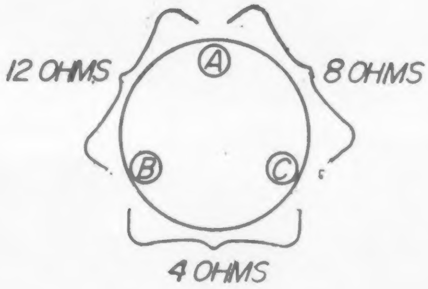
Starting with the top line and going from left to right number the terminals in order of common, start, run. Each terminal will be marked in order, then go to line two and line three, if necessary, marking each terminal in order.

Using the ohmmeter readings indicated find common, start and run.

1. A)________________________

B)________________________

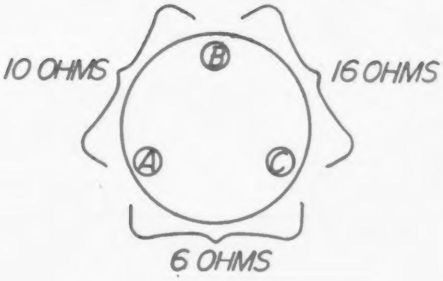
C)________________________



2. A)________________________

B)________________________

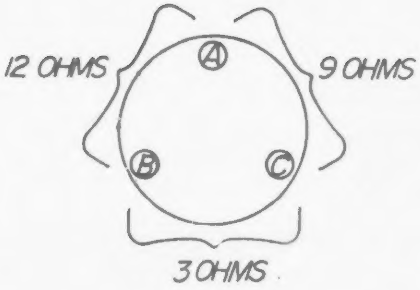
C)________________________



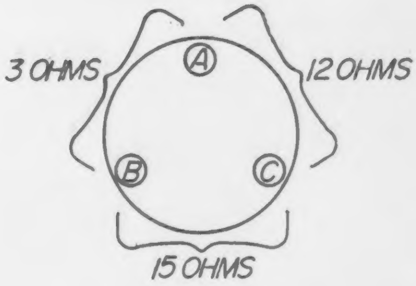
3. A)________________________

B)________________________

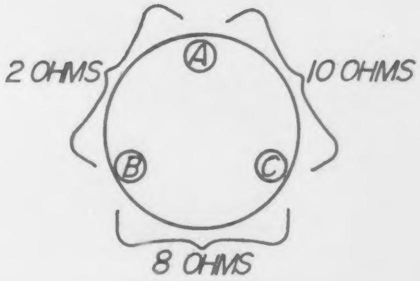
C)________________________



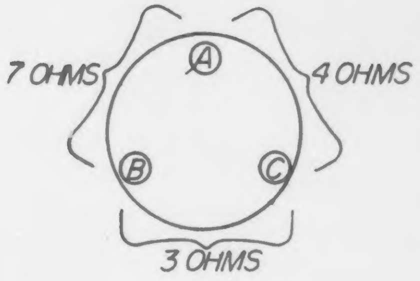
4. A)____________________
B)____________________
C)____________________



5. A)____________________
B)____________________
C)____________________

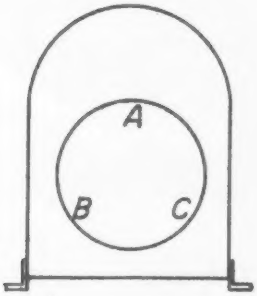


6. A)____________________
B)____________________
C)____________________

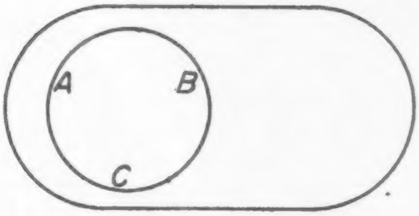


The following are Tecumseh-built compressors. Find common, start and run using chart.

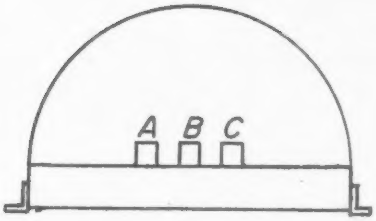
7. A)____________________
B)____________________
C)____________________



8. A)____________________
B)____________________
C)____________________



9. A)____________________
B)____________________
C)____________________

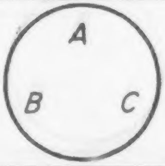


Test compressors using volt, ohmmeter

1. Check out VOM
2. Using compressors assigned by instructor find common, start, and run.

   Test for shorts, open, winding and ground.

   NOTE: You may not find C.R.S. if the compressor is shorted, open or grounded.

Compressor #	Draw diagram of Term. and indicate CRS	Short	Open	Ground
Example	A C B S C R 			✓
#1	A ______ B ______ C ______			
#2	A ______ B ______ C ______			
#3	A ______ B ______ C ______			
#4	A ______ B ______ C ______			
#5	A ______ B ______ C ______			

Compressor #	Draw diagram of Term. and indicate CRS	Short	Open	Ground
#6	A ____ B ____ C ____			
#7	A ____ B ____ C ____			
#8	A ____ B ____ C ____			
#9	A ____ B ____ C ____			
#10	A ____ B ____ C ____			

Direct Test Compressor

1. Check out compressor direct tester and safety glasses.
2. Using compressors tested in previous job sheet direct test only those compressors that checked O.K.
3. Connect test cord as indicated on tester. Connect common, start and run leads to compressor terminal. Connect capacitor leads together.
4. Turn tester on and push start button momentarily. If compressor runs do not operate for more than 10 seconds as damage could result to compressor. Turn tester off.
5. If compressor does not run, connect capacitor leads to a good capacitor size 88 - 108 MFD and 125 volt.
6. Repeat Step 4.
7. If compressor does not run it is stuck mechanically.

List Compressor # Checked	Compressor Runs	Compressor Stuck

Replacing Compressor

1. Mechanical Aspect
   - A. Check mounting to see if replacement component will fit.
   - B. Check size (if different, will it fit?)

2. Plumbing Aspects
   - A. Are compressor tubing connections in same place?
   - B. Are connections the same size?
   - C. Check for easiest way to reconnect tubing.
   - D. Can tubing be unsweated from compressor fittings and resoldered to new compressor?
   - E. If tubing is too short to reach fittings on the new compressor, will it be easier to first connect the tubing to the compressor or extend the tubing before settling the compressor in place?
   - F. If tubing must be cut in two pieces for replacement, where will the best place be to cut for ease of resoldering?
   - G. When tubing needs to be sweated to reconnect, if possible, sweat the tubing connection to the refrigerator and not to the compressor, as sweating may damage the compressor fitting.

   - H. CAUTION: Be careful where the flame is pointed when soldering.
     1. Keep away from insulation
     2. Keep away from cabinet
     3. Do not point at compressor

3. Electrical Aspects
   - A. Always install a new relay with a new compressor.
   - B. Check for proper terminal identifications as the replacement may be different than the original.

Replace Compressor

1. Check out all necessary tools, torch and safety glasses.
2. Using refrigerator assigned by instructor replace compressor.
3. Evacuate and charge

   NOTE:
   1. Refer to any previous unit information that you feel necessary
   2. A good technician does not always remember everything read, but should remember where to look for any information he/she may need when repairing an appliance.
4. Connect electrically
5. Operate unit and check temperature
6. Check with instructor before turning off refrigerator
7. Return tools and clean work area.

MAJOR BLOCK Refrigeration **NAME** ______

TASK Refrigerators and Freezers

UNIT Troubleshooting Refrigerators and Freezers **TIME (est.)** ______ **(act.)** ______

UNIT NO REF-38

OBJECTIVE(S)

Diagnose and locate problems in refrigerators and freezers.

START → W-1 L-1 C-1 W-2 L-2 C-2

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet REF-38a
W-2 Information Sheet REF-38b
W-3 ______
W-4 ______
W-5 ______
W-6 ______
W-7 ______

AUDIOVISUAL(S)

A-1 ______
A-2 ______
A-3 ______
A-4 ______
A-5 ______
A-6 ______
A-7 ______

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet REF-38a
L-2 Job Sheet REF-38b
L-3 ______
L-4 ______
L-5 ______
L-6 ______
L-7 ______
L-8 ______
L-9 ______

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 ______
C-4 ______
C-5 ______
C-6 ______
C-7 ______
C-8 ______
C-9 ______

Reading Wiring Diagrams

Any wiring diagram can be easy to use once it is understood. The easiest wiring diagram to follow is the ladder schematic (Figure A), in it the component that needs to be tested can be found quickly. The ladder schematic only shows how the components are connected electrically and does not show where the electrical connections are on the refrigerator. In using the ladder schematic, such as in Figure A, note that the components in a refrigerator fall into two categories:

A. Those that operate all the time,

1. perimeter heater
2. mullion heater

B. Those that have one or more switches to turn them off and on,

1. light (one switch)
2. defrost heater (two switches, defrost timer and defrost thermostat)
3. evaporator fan motor (three switches)

LADDER SCHEMATIC

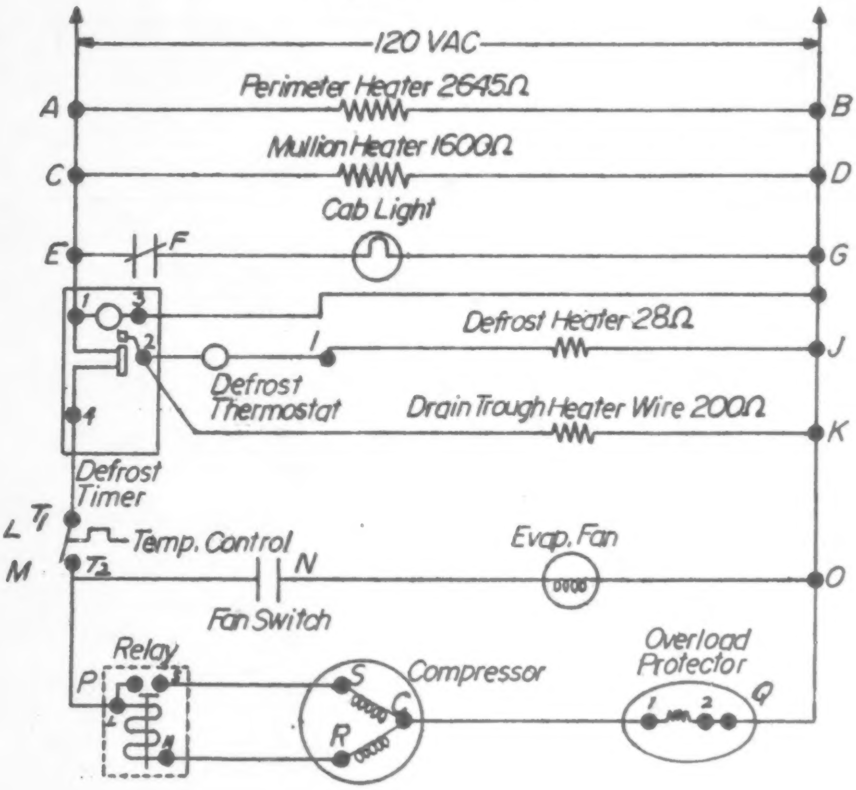


FIGURE A

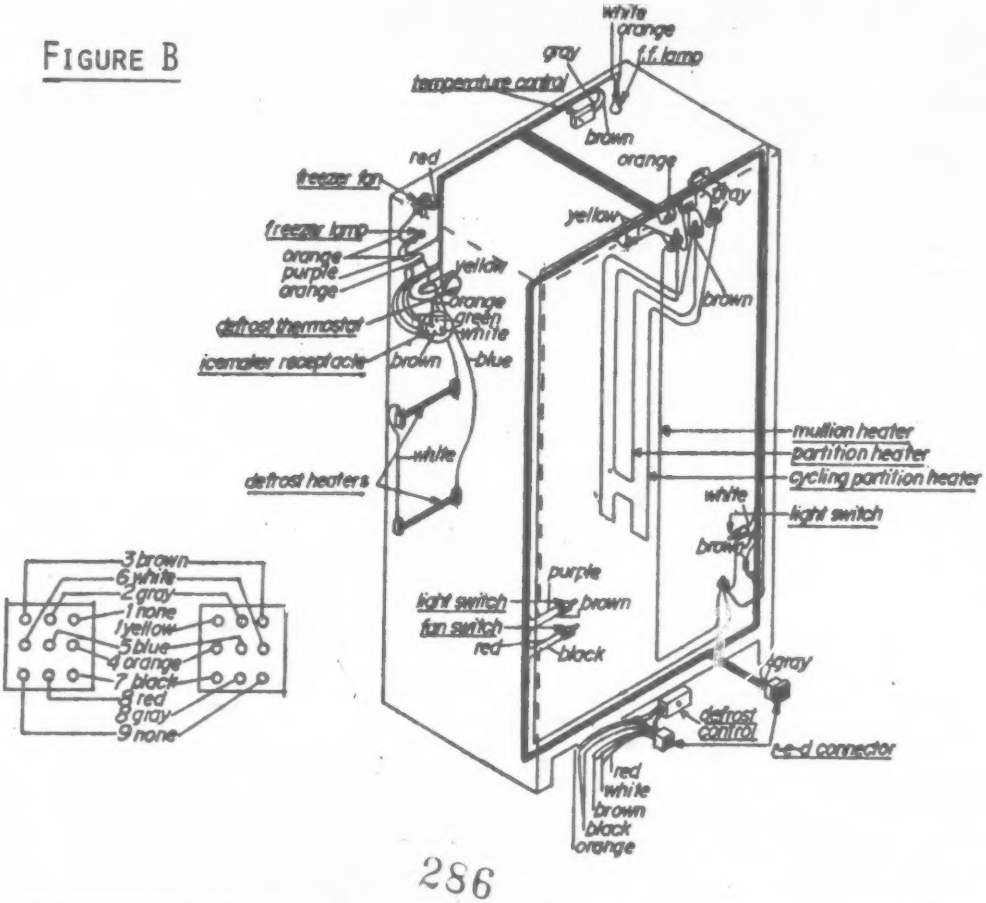
A pictoral diagram, shown in Figure B, illustrates where the component is and where the connections are located. As Figure B shows, it is harder to follow the wiring. First find the component, for example the freezer fan, then follow the wires by color. Follow the orange wire first. From the fan it goes to the light then continues on to a junction (crimp connector). From there it goes to a number of different components, the icemaker receptical, defrost thermostat and into the electrical harness. The orange wire makes a connection at the top of the cabinet and goes back through the wiring harness to the fresh food lamp and also continues on to the R-E-D connector.

Follow the red wire from the freezer fan into the wiring harness. It comes out and connects to the fan switch. Follow a few more wires in the diagram to become more familiar with reading it.

In testing, first locate the component to be tested and any associated switches. Then locate the test points. Then use the procedures discussed in previous sections to test the components.

In the wiring schematic the test point will vary. To test the perimeter heater follow the wires back from the heater to the crimp connectors. To test the heater for resistance disconnect one lead. If the heater check is alright reconnect lead. The evaporator (freezer) fan motor usually has spade connections at the fan motor. Remember that to test a component for resistance, the component must be isolated from the rest of the system.

FIGURE B



Use Wiring Diagram

1. Checkout VOM and any tools necessary.
2. Using a refrigerator assigned by instructor check the following components. NOTE: Use diagrams to locate component and test points.

COMPONENT	VOLTAGE READING ACROSS COMPONENT	RESISTANCE READING OF COMPONENT
Perimeter Heater		
Mullion Heater		
Fresh Food Light	Button Out	
	Button Depressed	
Fresh Food Light Switch	Button Out	
	Button Depressed	
Defrost Timer NOT IN DEFROST	Terminals 1 & 3	
	Terminals 1 & 2	
	Terminals 1 & 4	
Defrost Timer IN DEFROST	Terminals 1 & 3	
	Terminals 1 & 2	
	Terminals 1 & 4	
Temperature Control	Off	
	On	
*Defrost Thermostat TIMER IN DEFROST		
Defrost Heater TIMER IN DEFROST		
Freezer Fan	Button Out	
	Button Depressed	
Freezer Fan Switch	Button Out	
	Button Depressed	

*NOTE: Most thermostats open at 55° and close at 20°. Temperatures may vary with different units.

Information Sheet REF-38b

A chart for troubleshooting refrigerator and freezer problems:

Not cold enough.	1. Control settings	Usually set on mid position.
	2. Does evaporator fan work?	Self defrost only.
	3. Does condenser fan work?	Forced draft only.
	4. Dirty condenser.	
	5. Condenser blocked or restricted.	
	6. Evaporator fan blocked.	Freezer overloaded with food.
	7. Door gaskets.	
	8. Check temperature.	Freezer 0° to 10° Food Refrigerator 35° to 45° Temp.
	9. Short frost pattern.	See sytem diagnosis.
	10. Refrigerator light.	Does not turn off when door closed.
	11. Heavy frost build up.	See defrost system diagnosis.
		If all systems check correctly set thermometer colder.
Too cold.	1. Thermostat	Check settings or thermostat may be bad.
	2. Low capacitor compressor.	Non-frost free only, see compressor diagnosis.
Will not cool.	1. Thermostat.	Will not turn on.
	2. No power.	If light comes on you have power.
	3. Low voltage.	Refrigerator light dim.
	4. Compressor will not run.	See compressor diagnosis.
	5. Defrost timer.	Will not advance and stuck in defrost.
Noise	1. Tubing vibrating	Touch cabinet or another tubing.
	2. Fan motor.	Blade bent or mounting bad.
	3. Defrost timer.	Timer motor noisy.
	4. Compressor	A. mounting bad B. touching cabinet C. internal (replace)

Troubleshooting Refrigerators

1. Check out any tools and test equipment needed.
2. Using the troubleshooting chart in Information Sheet REF-38b and the assigned refrigerator diagnose problems.
3. Check with instructor before making repair.
4. Refer to any material or check lists as needed.
5. List briefly each step in your diagnosis and what you found.

A. Problem #1

Steps:

1.

2.

3.

4.

5.

The problem found is ____

____.

B. Problem #2

Steps:

1.

2.

3.

4.

5.

The problem found is ____

____.

C. Problem #3
Steps:

1.

2.

3.

4.

5.

The problem found is ______________________________

____.